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State Reaping Rich Reward From Scientific Cooperation

40101021B Beijing CHINA DAILY in English 23 Jul 92
p 4

[Text] China has made remarkable achievements in scientific and technological co-operation and exchanges with foreign countries since 1978, the year China started adopting reform and open policies, says Yao Weiwei in Science and Technology Daily. Excerpts follow:

China has now established scientific and technological co-operation and exchanges with 129 countries and regions. The Chinese Government has signed agreements on scientific and technological co-operation with 68 governments of the 129 foreign countries and regions. Most of the agreements were signed after 1978.

Institutions of scientific research and higher learning throughout the country have more active and broader co-operation and exchanges with their foreign counterparts.

For example, the Chinese Academy of Sciences has signed more than 50 agreements of co-operation with academies of sciences and institutions of scientific research in more than 30 countries and regions. The National Natural Science Foundation has established ties of co-operation with 12 foundations around the world. The China Association for Science and Technology and its academic institutions have joined 192 international scientific and technological organizations. One-third of China's 344 cities have had scientific, technological and economic exchanges with their sister cities abroad.

Each year, China sends delegations and scientists to meetings organized by the United Nations.

China now has ever-strengthening ties with the European Community. It, together with the Community, has more than 100 projects of co-operation in energy, information, bioengineering and nuclear safety technology.

Before 1978, only 500 Chinese attended international academic meetings abroad each year. In 1991 alone, 5,900 Chinese attended such conferences. China is also keen on holding conferences at home. In 1991, China organized 275 international academic conferences at home with 6,600 foreign participants.

Before 1978, China's scientific and technological co-operation and exchanges with foreign countries were mainly in the form of sending people abroad to make on-the-spot investigations, to attend international academic conferences, to visit and hold exhibitions and seminars on technology in China.

After 1978, the scope of exchanges became wider. Now, it includes joint research, design and development, investigation, exploration, co-sponsoring academic seminars, running labs, training centres and new and high-tech enterprises. Together with foreign countries, China sends scholars to international organizations to conduct joint research, invites foreign experts to China to offer technological consultation and conduct feasibility studies.

Before 1978, almost all international scientific and technological co-operation and exchanges were organized by organizations of the central government. Local governments were seldom the sponsors.

After 1978, the State established policies to encourage local governments to conduct scientific and technological exchanges with foreign countries. Now, there are more than 60 scientific and technological exchange centres throughout the country, contributing to the prosperity of local economies.

China has benefited from its co-operation and exchanges with foreign countries.

For example, through the introduction of production lines from foreign countries, China's home electrical appliance industry has become prosperous.

China's exporting of technology and technological products has been promoted. Between 1986 and 1990, China signed 1,110 contracts for technological exports with foreign countries totalling more than \$3.4 billion.

China has learned advanced foreign management techniques and technology.

For example, using foreign technology, China completed the Dayaoshan Tunnel project ahead of schedule. After seeking foreign experts' advice on the Gaobeidian sewage treatment project, the Beijing municipal government saved 19 million yuan (\$3.5 million) and 6.7 hectares of land.

Co-operation and exchanges with foreign countries have raised China's status in the world science and technology sector.

Now, 350 Chinese scientists hold positions in international organizations. Chinese acupuncture has been accepted by the world medical community. China has started launching satellites for foreign countries.

'Climbing Program' for Basic Research Launched

40101021A Beijing CHINA DAILY in English 23 Jul 92
p 1

[Article by Zhou Jie: "'Climb' on for Basic Scientific Research"]

[Text] China officially launched a long-term national science program—the "Climbing Program"—to accelerate investigations into key areas of basic science.

Thirty key subjects in the natural sciences were listed as the first group of research items to be tackled in the program. The subjects cover mathematics, physics, chemistry, biology, astronomy, agriculture, and medical sciences.

A total 30 million yuan (\$5 million) will be invested into the 30 subject areas by the State in each of the next five years. Each subject will receive 1 million yuan (\$170,000) annually from a special Climbing Program fund approved by Premier Li Peng.

Actual investment, according to an official with the program, will be far more.

About 6,000 top scientists and technicians in the country will contribute toward cracking the tough nuts in their disciplines.

Officials hope that the program will promote basic science study and lead to some major scientific breakthroughs, putting China in the thick of world scientific competition.

Speaking at yesterday's meeting to institute the program, Song Jian, Minister of the State Science and Technology Commission, said that China plans to make "first class" achievements on the frontiers of basic sciences in support of the country's development.

"A favourable and democratic working environment will be established for basic science study to allow for new academic ideas and nurture research talent," the minister said.

The program is part of the country's effort to maintain a limited number of crack researchers in basic sciences while pushing two thirds of the country's scientists and technicians into positions directly promoting China's economic

development, according to a source with the State Science and Technology Commission.

China has been weak in transferring scientific achievements into production. And the study of basic science has been troubled by limited funds, shared among too many subjects and scientists.

The first 30 subjects in the Climbing Program include high-temperature superconductivity research, non-linear science, nano-science and technology, theoretical physics, chemical problems in life science, and the function of the human brain.

The study of an ancient Chinese medical concept, Jingluo, was also listed in the program.

Scientists will also be asked to predict possible environmental changes in China over the next 50 years.

Other subjects include research into exploration for large mineral deposits, the theory of climate changes, cancer and processes for more efficient use of coal and oil.

China's Nine 'Silicon Valleys'

92FE0579C Beijing RENMIN RIBAO in Chinese
26 Apr 92 p 8

[Article by Li Shijia [2621 0013 0163]]

[Text] **Beijing Zhongguancun New Technology Industrial Development Zone:** "An Electronic Street" was formed by over 100 non-governmental high-tech companies, and over 40 computer development companies.

Shanghai Caohejing Microelectronic Industrial Zone: The focal points of this zone are the development of large-scale integrated circuits, robots, computers, and other cutting edge Chinese and foreign industrial technologies. There is great strength in this zone.

Tianjin Scientific and Industrial Zone: This zone stresses on the development of the following technologies: information, biology, precision chemical engineering, electro-mechanical integration, and new materials. The development also lays particular emphasis on the development of applied high-tech as well as the improvement of old and traditional enterprises.

Nanjing Pukou High, New-Tech Development Zone: A new Science City is founded based on the S&T Experiment Zones composed mainly of Nanjing Engineering Institute, Nanjing University, and Nanjing Aeronautics Institute joined by the key research institutes and business conglomerates in this area.

Guangzhou Wushan S&T Zone: The zone introduces advanced technology, capital, and S&T information to form a unified R&D center of higher education, production and sale. It features a strong open policy to the outside.

Wuhan Donghu New Technology Development Zone: Its target is to revise the industrial structure in Wuhan by utilizing new domestic and foreign technologies.

Chongqing Shapingba Experimental Zone for Science, Technology, and Industrial Development: Based on the numerous institutes of scientific research of Chongqing University and 11 other colleges, and coordinated with the most economically developed and populated Shapingba district in Chongqing area, this zone has, up to now, over 100 licensed business enterprises in operation.

Shenzhen Science and Technology Industrial Zone: Based on China's S&T strength with emphasis on joint venture of China and foreign investment, a zone of multi-economic components was established. This zone is devoted to the research, development and manufacturing of intelligence intensive products.

Changsha Experimental Zone of S&T Development: The zone was started in July 1988. Within a month, over 140 units applied to establish their modern high-tech businesses in this area. The establishment of this zone will become an asset to the development of modern high-tech in Hunan.

(Selected by Li Shijia from "Information Card-File," No. 4, 1992)

Construction of Taiyuan High, New-Tech Industrial Development Zone Accelerated

92FE0579A Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 15 May 92 p 6

[Article by Wang Xin [3769 2500]: "Shanxi Accelerating Construction of Taiyuan High, New-Tech Industrial Development Zone"]

[Excerpts] [Passage omitted] Taiyuan is the key city of energy and heavy industry and chemical industries in Shanxi. In the Taiyuan High, New-Tech Industrial Development Zone (THNDZ), there are nine higher education institutes, 10 institutes of scientific research or design of the Central Government, over 30 scientific research institutes of the Provincial and City Governments and several tens of privately managed scientific research organizations. There are 15,000 personnel (over one-third of the total of the similar personnel in Shanxi Province) working in the fields of scientific research and S&T development. The industrial technology and business foundation in Taiyuan are comparatively solid. There are 25 large and medium-sized industries, a considerable number of which are key industries in China. Up to now, 89 high, new-tech businesses have entered THNDZ. They manufacture 185 different items of high, new-tech products in the following areas: energy, electronic information, electromechanical integration, photo-electricity, laser, environmental protection and energy conservation, precision chemical engineering, etc. Thirteen items of the above reached the advanced international level of the 1980's. Sixty-five items reached the advanced national level. Twenty-four items were patented. Fifteen items won the Science and Technology Achievement Awards issued by the ministry or the province.

On 6 July of last year, Shanxi Provincial Government approved the establishment of THNDZ and asked Taiyuan to manage THNDZ as a special region which will be managed and supported by the entire Party, and society. The People's Provincial Government approved and formulated the "Certification procedure of high, new-tech industry in THNDZ," and the "Provisional policies and rules for THNDZ," "Rules for tax revenue policy for THNDZ," and "Opinions on the use of preferential policy for the basic construction of THNDZ." These regulations clearly stated an overall open, reform policy system in THNDZ. The following subjects are explicitly stipulated: THNDZ's management structure and operation procedures, capital construction, finance and credits, import and export management, labor and personnel. The Municipal Bureau of Industry and Commerce and the Bureau of Taxation have established a special office in THNDZ. This office unifies the management of industry, commerce, administrative affairs and taxation in THNDZ. The City Center of Qualified Personnel Exchange established an Exchange Center in THNDZ, thus providing the condition for reforming workers' affairs, and reasonable transfers of science and technology personnel. This April, the Shanxi Science Commission and the Provincial System Reform Commission published their "Opinions on intensifying the reform of THNDZ and promoting the implementation of high, new-tech industry in Shanxi" and further recommended the realistic targets of accelerating the development of THNDZ. Up to now, under the concerned leadership of the State

Science and Technology Commission and the Provincial Science Commission as well as the strong support of different authorities, all the development works of THNDZ have proceeded smoothly. This fact indicates that THNDZ has great potential and vitality. By the end of 1991, the total income of 65 businesses in the zone amounted to 70,790,000 yuan. They had paid a profit tax of 10,430,000 yuan. On 12 November 1991, the State Science and Technology Commission approved THNDZ as a Development Zone on the Provincial Level.

The State Science and Technology Commission is going to inspect and certify several high, new-tech industrial zones such as THNDZ. They will recommend to the State Council the promotion of those qualified zones to become National Development Zones. [passage omitted]

Therefore, THNDZ has to go a step further to establish and to perfect the socialized support service system and social security system; to create flexible environment; to attract capital, technology, and qualified personnel; as well as to promote the commercialization, industrialization, and internationalization of high, new-tech products. Thus, THNDZ will activate the economic take-off of Taiyuan and even that of Shanxi Province.

We should be bolder with "Reform and Open Door Policy"; courageous to experiment; daring to lead, in order to manage well the Shanxi comprehensive reform experimental region.

—Implement "One Factory-Two Systems." A superior unit will be organized out of a medium or large enterprise utilizing the existing material, technology, and personnel to undertake certain production elements. The main function of this unit is to produce and manage high, new-tech products. This unit is a newly developed entity with independent accounting system—"a factory within a factory (FWF)." The original factory and the newly established FWF will have two different administrative and management systems. The operation system of the FWF will infiltrate and influence the original factory and gradually convert and replace the original managing system.

—Implement Shareholding System. The City System Reform Commission has certified that THNDZ is an experimental zone for shareholding system. Any new business in the zone is allowed to become a shareholding company with investment from various economic components.

—Bravely conduct financial reform. Different financial policies will be formulated. The direct investment system such as stocks, and bonds will be gradually experimented.

Reform pace should step up, must be "daring" and "risk taking."

—THNDZ must adopt international standards as soon as possible in order to meet the international practices, systems, conventions, and environmental conditions.

—THNDZ must simplify the application process for "3-capital" (joint venture) businesses, and implement the "one-step examination and approval" policy for the initiation, contract, charter, and registration of businesses.

—THNDZ should aggressively invite foreign businessmen; people from Taiwan, Hong Kong, and Macao; and overseas Chinese to establish modern high-tech businesses. Competitive advantages as compared to other regions should be provided.

—THNDZ should establish warehouses, factories, or zones enjoying special tax benefits.

Work should be more practical, more precise, never loosen the grip, and stick with achieving real results.

—In THNDZ, a batch of accomplished products with market potential, and influence should be selected. These items will be mass produced, and will become the industrial symbols and images of THNDZ products.

—THNDZ should create favorable investment environment, and speed up construction to present the stereoscopic image of reasonable planning of the entire zone. By grasping the market, promoting production, and activating the circulation, complete the "S&T Market" of THNDZ and THNDZ's facilities, and a 0.5 square kilometers new development district. In the next stage, the construction of a 1.3 square kilometers new district with three S&T streets will be completed. By the year 2000, the construction of a 4 square kilometers new zone will be completed.

The THNDZ strategic targets are as follows: THNDZ will expand to 120 businesses by the end of this year. Several export-type businesses will be built up. A few export bases will be developed. Total income of the science and technology trade will reach 200 million yuan. By 1995, the number of high, new-tech businesses in THNDZ will reach 200. Total S&T trade will be 500 million yuan; profit tax, 82.27 million yuan; and foreign exchange saving, US\$14 million. By the end of 2000, the number of high, new-tech businesses will reach 500. Total S&T trade will be 1.2 billion yuan; profit tax, 197 million yuan; and foreign exchange saving, US\$33 million. [passage omitted]

S&T Development Center Established in Xiamen

92FE0579D Shanghai JIEFANG RIBAO in Chinese
11 May 92 p 3

[Article by Yu Yingrei [0151 3841 3843]: "Cooperation Between SSTC and Xiamen; Establishing Branch of CSTDI; Promoting Internationalization of High-Tech Industries"]

[Text] Based on Xinhuashe Xiamen 10 May Telegraph (Reporter Yu Yingrei)—Yesterday the State Science and Technology Commission (SSTC) and the City of Xiamen signed an agreement establishing the Xiamen Branch of China Science and Technology Development Institute (XB-CSTDI) as well as the International Commercial City of Science and Technology (ICCSST).

This organization is aimed at taking advantage of the following combined conditions: inland science and technology personnel and accomplishments, superior geographic location and certain political policies of Xiamen, and the progressive financial, trade, and information capabilities of Taiwan and Southeast Asia. The organization will promote the internationalization of China's high-tech

industries, the economic development of the above-mentioned regions, the economy and S&T exchange between both sides of Taiwan Strait, and the peaceful unification process of China.

Based on market demands of Taiwan, Southeast Asia and other foreign countries, XB-CSTDI will take up customers' assignments of development and consultation projects, establish service center for establishing new enterprises, and recommend projects for high-tech industry development zones. Under the dual leadership of the SSTC and Xiamen Municipal Government, XB-CSTDI will adopt business management method. Each center or office within the institute could be established through single party financing, domestic and foreign joint investment, Chinese and overseas cooperation, or a corporation within the institute. The function of ICCST is to become a coordinated part of Xiamen high, new-tech industrial development zone.

Taisen Computer Research Center Profiled

92FE0579B Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 15 May 92 p 6

[Article by Xu Liang [1776 5328]: "Taisen—New Star in Great Tide of Reform"]

[Text] Era of reform; new stars emerging in large numbers.

A significant new star, Taisen Computer Research Institute (TCRI) in Taiyuan, emerged from the great tide of reform.

TCRI was established in October 1989 by seven Master's candidates and college students. Their target is aimed at applying scientific research results to actual production in the shortest possible time.

In the beginning, Taisen closely followed the trend of computer technology development. Their motto is "Survival on good reputation. Development through technology." Their visions are concentrated on development projects such as computer-aided design (CAD), computer network communication (MC), management information system (MIS) and industrial control. They successfully developed the supply network system for Wangzhuang Coal Mine, Bureau of Mines in Lu'an; multiple users' management information network for the Pingshuo Guest House of Antaibao Open Coal Mine; and a dozen other science and technology applications. In October 1990, they won the National Science and Technology Achievement Third Award for their development of the architecture CAD software (a joint project with the Institute of Installation Design of the City of Taiyuan). On the hardware side, TCRI with its abundant strength in the field of industrial control and electromechanical integration, developed industrial supervision system, and a.c. frequency conversion speed regulators controlled by microcomputers. Some of the regulator performance data have exceeded those of similar foreign products and were praised by the users.

In the past 2 years, TCRI has been continuously expanding the computer software and hardware services resulting in social and economic benefits. At the same time, in order to enhance its internal build-up, TCRI invested about 1 million yuan for the purchase of computer workstation, and 486 microcomputer as well as forming a direct network with businesses of the same trade in China. The computer

management information system in TCRI has attained the modern management level. Step by step, TCRI personnel has worked out an operation system of rational technical organization and good management. TCRI has now developed into a modern high-tech enterprise with multi-million yuan assets, integrating technology, labor, and trade. TCRI is one of the first industries admitted into the Taiyuan High, New-Tech Industrial Development Zone (THNDZ).

Recently, Taiyuan City Restructuring Commission and Administrative Commission of THNDZ approved the name change from TCRI to Taiyuan Taisen Computer Co., Ltd. which was certified as an experimental stock enterprise. At the same time, a company named Lande Computer Software (Taiyuan) Co., Ltd. was established by TCRI with investment from Hong Kong.

TCRI, the new outstanding performer in Taiyuan computer market will march into the world market from the great province of Shanxi.

Russian Scientific Delegation on Visit to PRC

LD1907183292x Moscow Mayak Radio Network in Russian 1430 GMT 17 Jul 92

[Text] A Russian scientific delegation headed by Vladimir Shorin, chairman of the Russian Supreme Soviet Committee on Science and National Education, was in China for almost a week. Our correspondent in Beijing, Vladimir Kulikov, reports:

[Kulikov] Before the flight back to the homeland, I interviewed Shorin, who highly appraised the prospects for scientific cooperation between the two countries. If before he said that relations between us are built at the level of state structures and proceed mainly via government organizations, then now both sides intend to attract enterprises, establishments, higher educational establishments, and a greater number of people into the sphere of cooperation.

During a talk between members of the delegation and Li Tieying, chairman of the PRC State Education Commission, the broadest range of questions connected with cooperation in the sphere of education, science, and technology were discussed. We agreed, stressed the Russian parliamentary deputy, that a Russian-Chinese university will be created as the latest expression of our humanitarian ties.

As for scientific and technical cooperation, the question was worked through of closer contacts with the Academy of Sciences in China and of more intensive training of specialists in the sphere of the Chinese language. These and other proposals will form the basis for a treaty on scientific and technical cooperation which both sides plan to sign at the end of this year. Chinese work experience in special economic zones, in particular in Shenzhen in southern China, which the guests from Russia visited, especially interested the members of the delegation. In particular, the experience of using land for foreign investors when the land is not sold but leased for 50 years, which is advantageous for both sides, has proved valuable for China. The infrastructure of small industrial enterprises set up in free economic zones, multi-stage conversion in military production, and many other things interested the delegation.

FG-15 Apogee Solid Rocket Motor Introduced

92P60364A Beijing ZHONGGUO HANGTIAN
[AEROSPACE CHINA] in Chinese No 6, Jun 92
pp 37-39

[Article by Ruan Chongzhi [7086 1504 2535], assistant general manager and research fellow, Northwest Chemical Power Co.: "Development of Solid Rocket Propulsion Technology"]

[Excerpt] [Passage omitted]

Taking as an example the FG-15 apogee solid rocket motor [see photograph, Figure 2, below] used on board the DFH-2 geosynchronous communications satellites, one can clearly see the technical level of the nation's solid rocket propulsion technology.

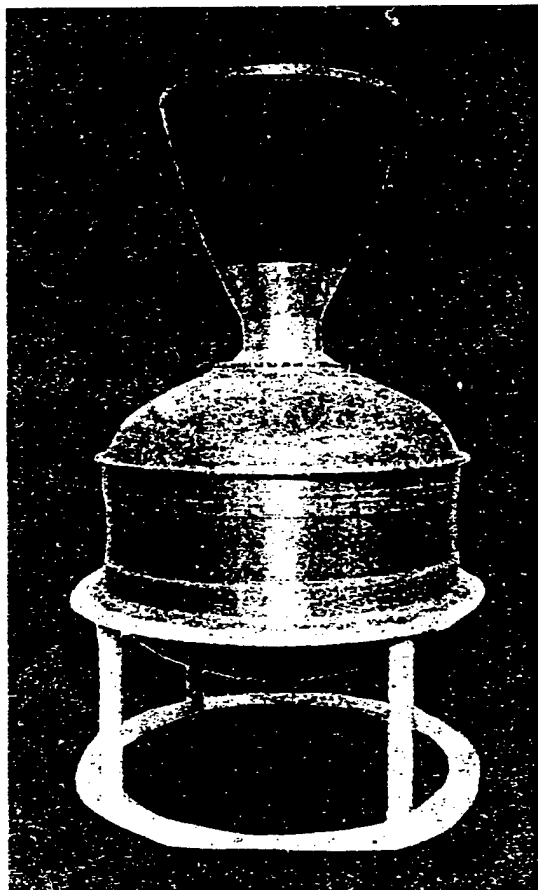


Figure 2. Domestically Developed FG-15 Apogee Motor

1. Main Performance of the FG-15 Motor

Maximum external diameter	896 mm
Overall length	1,420 mm
Gross weight	510 kg
Propellant weight	443 kg
Vacuum specific impulse	2,832 N-s/kg
Operating pressure	4.0 MPa
Operating time	32 s
Mass ratio	0.87

2. Technical Standards of the FG-15

The FG-15 motor's design was adopted in 1976, and the first successful launch with this motor was on 29 January 1984. The FG-15 incorporates several currently advanced technologies: a glass-fiber wound composite case, HTPB (hydroxyl-terminated polybutadiene) composite propellant with 87-percent solid components, a carbon-carbon composite throat liner, a boron-nitric acid-potassium igniter suitable for a high-vacuum environment, and a micromotor-type safety-ignition mechanism.

The domestic solid rocket industry has now mastered HTPB propellant technology to a relatively high degree. The main performance parameters for this type of propellant are: standard-state (sea level, pressure ratio of 70/1) theoretical specific impulse = 2,587 N-s/kg; high-, low-, and normal-temperature propellant extensibility > 40 percent; burning rate is in the 3-30 mm/s range.

The glass-fiber wound composite case fabrication technique is also now relatively mature; maximum container efficiency ($P \times V/W$) has reached 18 km. With the efforts now underway to develop organic fiber and carbon fiber composite materials, it is estimated that container efficiency can be increased to 30 km or more.

Carbon-carbon composite materials possess excellent resistance to high temperatures, and are therefore especially suitable for solid rocket motor nozzle construction. Their successful application in fabricating the convergent section and the throat liner has already been realized, and research is now in progress to use these materials in the divergent section.

The FG-15 operates in a vacuum environment. Therefore the most important issue is to resolve the ignition reliability problem, while a second important issue is construction of a ground-based high-altitude simulation testing facility, with which one can determine the vacuum specific impulse.

The boron-nitric acid-potassium igniter's burning rate is independent of pressure (pressure coefficient $n = 0$), so it has been selected as an ideal igniter for motors started in a high-vacuum environment. Also, a reliable airtight structure has been designed; a gas-filled space around the FG-15 motor maintains the intra-cavity pressure at above atmospheric pressure for a long time.

High-altitude simulation test runs require a jet-induced-flow apparatus [i.e., wind tunnel], and to save on

expense one should select a passive induced-flow mechanism. Therefore in the rising-pressure segment and near-descent segment, the cabin pressure varies greatly, influencing testing accuracy. The currently used correction technique can still be applied for FG-15-type motors.

3. Reliability of the FG-15 and Its Improved Model

After the successful launches with the FG-15 rocket motor, an improved, extended-length model—the FG-15B rocket motor—was designed and developed, and first launched successfully on 7 March 1988. As of 29 December 1991, FG-15 and FG-15B solid rocket motors have carried out tasks in seven launches, all successful, demonstrating their very high reliability. The FG-15B motor has received a State Product Quality Gold Medal.

**Missile Warhead Surface Ablation Analyzer,
Simulator Tank-Target Real-Time Tracking
System Certified**

92P60383A Beijing JISUANJI SHIJIE [CHINA
COMPUTERWORLD] in Chinese No 26, 1 Jul 92 p 2

[Article by Zhang Guoliang [1728 0948 2733]: "Two Systems Developed by Xian Jiaotong University for National Defense Research Fill a Domestic Void"]

[Summary] Two defense R&D projects of the Artificial Intelligence & Robotics Institute at Xian Jiaotong University—the development of a "missile warhead surface ablation image analysis system" and of a "simulation trainer tank-target real-time tracking system"—recently passed the expert technical appraisal organized by the Shaanxi Province Education Commission. The former system,

overcoming the cumbersome and insufficiently accurate measurement associated with the conventional mechanical technique, is designed to provide a highly automated, highly accurate (contour curve-fitting error less than one pixel) measurement technique for in-depth study and description of the dynamic processes affecting missile warhead surfaces. Such an advanced high-tech system has not been reported abroad. The latter system is designed to provide automated real-time positioning and tracking of the projected tank targets used in simulation trainers for antitank-missile-equipped helicopters. Image real-time tracking technology has not yet been implemented in comparable foreign-made armored helicopter simulators. The appearance of this system represents a major boost to the domestic development of weapons guided by precision projected-image tracking.

Synthesis and Crystal Structure of a New Compound, $\text{Al}_3\text{Nb}_5\text{O}_{16}$

40100068B Beijing GUI SUANYAN XUEBAO
[JOURNAL OF THE CHINESE CERAMIC SOCIETY] in Chinese Vol 20 No 2, Apr 92 pp 156-162

[English abstract of article by Ouyang Shixi, Zha Congji, and Wu Bolin of the Institute of Advanced Materials of Wuhan University of Technology, and Wu Qiangjin and Lu Shaofang of Fujian Institute on Matter Structure, CAS; MS received 21 Dec 90]

[Text] In the binary system $\text{Nb}_2\text{O}_5\text{-Al}_2\text{O}_3$, a new compound $\text{Al}_3\text{Nb}_5\text{O}_{16}$ was synthesized by the flux method at 1300°C in a weak reducing atmosphere, and its X-ray powder pattern data were obtained. Crystal data from single-crystal are as follows: $a = 12.172(6)$ Angstroms, $b = 3.740(1)$ Angstroms, $c = 6.486(2)$ Angstroms, $\beta = 107.67(3)^\circ$, $V = 281.3(4)$ Angstroms³, $Z = 1$, $D_m = 4.74$ g/cm³, $D_c = 4.73$ g/cm³, $F(000) = 372$, $\mu(\text{MoK}\alpha) = 48.52$ cm⁻¹. For 424 unique refractions with an intensity greater

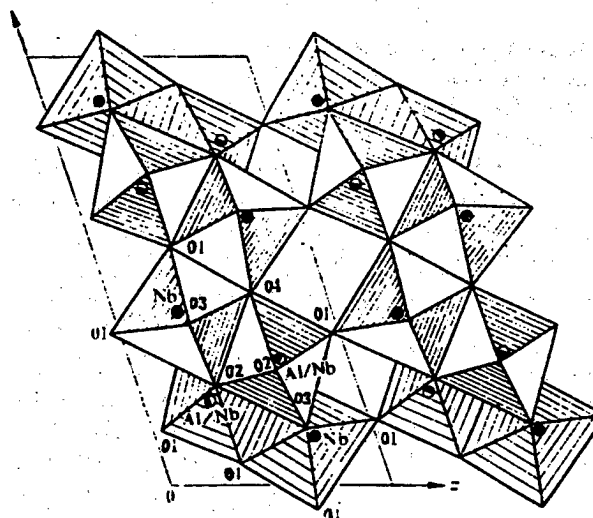


Figure 1. The Projection Along the b-Axis of $\text{Al}_3\text{Nb}_5\text{O}_{16}$

Table 1 The results of chemical analysis of the crystal

Atom (mol%)			Mole ratio	Formula
Nb ⁵⁺	Nb ⁴⁺	Al ³⁺	Nb ⁵⁺ :Nb ⁴⁺ :Al ³⁺	$\text{Al}_{3.08}\text{Nb}_{4.97}\text{O}_{16.32}$
36.5	21.6	37.9	2.97:2:3.08	

Table 3 The intensity data collection conditions and crystal data

Diffractometer	Rigaku AFC5R
Monochromator	Graphite
Radiation	$\text{MoK}\alpha(\lambda = 0.71069 \text{ \AA})$
Temperature	23°C
Voltage	50kV
Current	120mA
Scanning mode	$\omega-2\theta$
Scanning range (2θ)	$3^\circ-100^\circ$
Crystal dimension	$0.05 \times 0.05 \times 0.4(\text{mm}^3)$
Linear absorption $\mu(\text{MoK}\alpha)$	48.52cm^{-1}
Scanning rate	$16^\circ/\text{min}$
Scanning width	$\Delta\omega = (1.628 + 0.350\tan\theta)^\circ$
Molecular formula	$\text{Al}_3\text{Nb}_5\text{O}_{16}$
Formula weight	801.46
Crystal system	Monoclinic
Cell dimension	$a = 12.172(6) \text{ \AA}$ $b = 3.740(1) \text{ \AA}$ $c = 6.486(2) \text{ \AA}$ $\beta = 107.67(3)^\circ$ $V = 281.3(4) \text{ \AA}^3$
Cell volume	C2/m
Space group	1
Z value	4.73g/cm ³
D_{calc}	4.74g/cm ³
D_m	372
$F(000)$	

Table 5 Main interatomic distances (Å)

Metal—Oxygen			
Nb(1)—O(1)	1.769(4)	Al(1)/Nb(2)—O(1) <i>c</i>	1.754(4)
—O(4)	1.860(3)	—O(4) <i>b</i>	1.830(3)
—O(4) <i>b</i>	2.288(3)	—O(3) <i>d</i>	2.012(3)
—O(3)	1.952(1)	—O(2) <i>e</i>	1.940(1)
—O(3) <i>a</i>	1.952(1)	—O(2) <i>d</i>	1.940(1)
—O(2)	2.200(3)	—O(2)	2.133(3)
Metal—Metal			
Shared edge octahedron		Shared corner octahedron	
2 × Nb(1)—Al(1)/Nb(2)	3.159(2)	2 × Nb(1)—Nb(1)	3.740(1)
Nb(1)—Al(1)/Nb(2)	3.314(2)	Nb(1)—Al(1)/Nb(2)	3.513(2)
Nb(1)—Nb(1)	3.289(2)	Nb(1)—Al(1)/Nb(2)	3.556(2)
2 × Al(1)/Nb(2)—Nb(1)	3.159(2)	2 × Al(1)/Nb(2)—Al(1)/Nb(2)	3.740(1)
2 × Al(1)/Nb(2)—Al(1)/Nb(2)	3.133(3)	Al(1)/Nb(2)—Nb(1)	3.556(2)
Al(1)/Nb(2)—Nb(1)	3.314(2)	Al(1)/Nb(2)—Nb(1)	3.513(2)

a—*x*, 1+*y*, *z*; *b*—1−*x*, 1−*y*, 1−*z*; *c*—*x*, *y*, 1+*z*; *d*— $\frac{1}{2}$ −*x*, $\frac{1}{2}$ −*y*, 1−*z*;

e— $\frac{1}{2}$ −*x*, $\frac{3}{2}$ −*y*, 1−*z*

than 15 σ(I), the final agreement factors are $R = 0.023$, $R_w = 0.032$. The structure may consist of edge-shared and corner-shared NbO_6 and AlO_6 octahedra; the atoms Nb and Al are located at the vacants of the octahedra, but a fraction of Al in the lattice is replaced by Nb atoms, and there are Nb^{5+} and Nb^{4+} in the compound.

The Growth and Characterization of Photorefractive BaTiO_3 Single Crystal

40100068C Beijing GUI SUANYAN XUEBAO
[JOURNAL OF THE CHINESE CERAMIC SOCIETY] in Chinese Vol 20 No 2, Apr 92 pp 163-168

[English abstract of article by Zhao Tongrong and Zhang Daobiao of Shanghai Institute of Ceramics, Chinese Academy of Sciences; MS received 5 Nov 90] [Text] Tetragonal single-crystal of barium titanate (BaTiO_3) is a kind of newly developed nonlinear optical crystal, which may be used extensively in optics because of its wide range of nonlinearity.

In this paper, the growth of bulk BaTiO_3 single crystals by top-seeded solution growth technique, using two synthetic raw materials, is described. Structural and component

analyses, crystallographic characterization and the measurement of Curie temperature and transmittance for the as-grown crystals are reported. The optimal conditions for growing excellent BaTiO_3 single crystals are proposed [crystal rotation rate over 10 rpm, temperature reduction rate about 0.1°C/h, and pulling rate of 0.1-0.5 mm/d].

High-Rate Synthesis of Diamond Film by DC Plasma CVD

40100068A Beijing GUI SUANYAN XUEBAO
[JOURNAL OF THE CHINESE CERAMIC SOCIETY] in Chinese Vol 20 No 2, Apr 92 pp 143-146

[English abstract of article by Wang Wanlu, Gao Jinying, and Liao Kejun of the Department of Physics, Lanzhou University; MS received 19 Feb 90]

[Text] Diamond thin films have been deposited by DC plasma chemical vapour deposition (CVD) with a high growth rate ($\approx 80 \mu\text{m/h}$) at low pressure ($\approx 2.66 \times 10^4 \text{ Pa}$), which is about 80 times faster than that in the conventional chemical vapour deposition technique. Crystalline structure of the diamond film was examined by means of X-ray diffraction, scanning electron microscopy and Raman spectrometry. The experimental results are also discussed briefly in the paper.

Jilin To Export Anti-AIDS Medicine

OW0607043192x Beijing XINHUA in English 0321
GMT 6 Jul 92

[Text] Changchun, July 6 (XINHUA)—Northeast China's Jilin Province will export its newly developed traditional Chinese medicine called "Milingwang", which is believed to be able to prevent and cure the disease of AIDS (acquired immune deficiency syndrome).

According to a contract signed recently between the Jilin Provincial Technological Import and Export Company and Finehandle Limited Aps of Denmark, Jilin Province is expected to provide the Danish company with 40 tons of "Milingwang" capsules worth 260 million U.S. dollars a year. The first group of "Milingwang" capsules will be exported to Denmark in October.

The medicine was developed after many years' effort by Lin Haifeng, director of the Tonghua Institute of Medicines for AIDS Prevention and Cure, combining his related secret recipe handed down from generation to generation with contemporary theories of medical sciences.

Reports based on experiments from the Chinese Academy of Preventive Sciences and Dr. Bethune Medical University prove that the medicine can effectively control the propagation of the AIDS virus and can also enhance the immunity of an organism, but does not harm the liver or kidney of the human body.

Clinical tests have also been carried out in southwest China's Yunnan Province, Argentina, Brazil, and Tanzania and research reports show that the medicine has certain curative effects over some AIDS patients.

Local officials said "Milingwang" medicine will soon be batch produced by the Tonghua No. 2 Pharmaceutical Factory in the province.

Academy of Military Medical Sciences' New Drug R&D

92P60390A Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 4 Jul 92 p 1

[Article by Zhang Shi [1728 4258]]

[Summary] Faced with fierce international competition to develop new drugs, the Chinese Academy of Military Medical Sciences (CAMMS) has determined to meet the challenge. After a long search for new ways to develop new drugs, CAMMS has found five categories of new techniques: looking for new chemical structures; reconstructing the existing drugs; purifying pharmaceutically active substances (monomers) from naturally existing plants and animals; further studying compounds with known structures; and using new technology to prepare compounds of several ingredients. The development of benzofluorol (Benwuchun), a brand-new chemical screened from a countless number of compounds, brought for the academy the only national-level invention award in the pharmaceutical arena. The academy now has the capability to synthesize new drugs using the above-mentioned five categories of new technologies, and is capable of completing research

work on the 26 indicators including drug pharmacology, curability, and safety stipulated by the state.

Attenuated Hepatitis A Vaccine Put Into Large-Scale Production

92P60390C Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 26 May 92 p 1

[Article by Qu Mingguang [1448 2494 0342]]

[Summary] The attenuated hepatitis A vaccine jointly developed by the Kunming Biology Institute of the Chinese Academy of Medical Sciences and the Zhejiang Academy of Medical Sciences in 1988, has been approved by the Ministry of Public Health for large-scale production. The production line will increase its production capacity 3-5 fold over last year's 200,000-dose capacity. Tests on 100,000 people in seven provinces including Hunan, Guangdong, Sichuan, and Yunnan indicate that the vaccine has no side effects. Antibodies against hepatitis A were detected in 95 percent of the test group.

Success in Cloning, Sequencing Hepatitis C and E Viruses Genome

92P60390D Beijing YIYAO XINXI LUNTAN [CHINA MEDICAL TRIBUNE] in Chinese Vol 18 No 25, 25 Jun 92 p 1

[Article by Wei You [4850 0645]]

[Summary] Liu Chongbai [0491 1504 2672] of the Virology Institute of the Chinese Academy of Preventive Medicine has cloned the complete genome of the Chinese strain of hepatitis C and hepatitis E (non-A, non-B) viruses and has studied their complete nucleic acid sequences. The institute jointly conducted the project with the U.S. Center for Disease Control in developing a new viral RNA extraction method, studied the primary structure of hepatitis E virus genome and cloned the complete sequencing of hepatitis C virus genome. The study discovered that viral strains from Hebei and Shanghai are similar with some differences in structural genes. It was also found that genomes of the Chinese strains are close to the Japanese strain, but it is much closer to European and U.S. strains than to the Japanese strain. The success has led the institute to the development of hepatitis C diagnostic reagents and the launching of genetically engineered hepatitis C and hepatitis E vaccine research.

Success in Human-Plant Gene Recombination

92P60390E Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 6 Jul 92 p 3

[Article by Zhang Jimin [1728 4949 3046]]

[Summary] The Genetics Institute of the Chinese Academy of Sciences has succeeded in human-plant gene recombination by expressing human interferon gene in plants. In an effort to explore new ways to produce large quantities of human interferon, the institute succeeded in conducting research on expression of human interferon in tobacco plant in 1988. Last year, the institute collaborated with the Virology Institute of the Chinese Academy of Preventive Medicine, and again succeeded in expressing human interferon in paddy rice. Application of plant

genetic-engineering technology in producing biological pharmaceuticals, which are urgently demanded in China, will lower China's pharmaceutical costs to about 1 percent of the cost using conventional methods.

Antidotes Against Nereistoxin Developed

92P60390B Beijing YIYAO XINXI LUNTAN [CHINA MEDICAL TRIBUNE] in Chinese Vol 18 No 27, 9 Jul 92 p 1

[Article by Zheng Rongyuan [6774 2837 6678] and Lu Zhongqiu [4151 0022 4428]]

[Summary] A research group led by Chen Zhikang [7115 1807 1660] of Fujian Wenzhou Medical College has developed two antidotes specially for detoxicating cases of poisoning from the widely used pesticide nereistoxin. The two chemicals, dimercaptopropanesodiumcarbonate (DMPS) and dimercaptosodium succinate, were found capable of stopping acute respiratory muscle arrest caused by nereistoxin poisoning. Clinical tests conducted on 38 patients suffering from acute nereistoxin poisoning have proven that in small doses the two antidotes bring quick relief. They are also effective in treatment non-metal-toxin poisoning.

Experimental Study of Antagonizing Effect of Calcium and Magnesium Against Fluoride Toxicity in Collagen

40091017A Beijing ZHONGHUA YUFANG YIXUE ZAZHI [CHINESE JOURNAL OF PREVENTIVE MEDICINE] in Chinese Vol 26 No 2, Mar 92 pp 80-82

[English abstract of article by Chen Guoli [7115 0948 4539], Huang Changlin [7806 2490 2651], et al., of the Research Center for Prophylaxis and Treatment of Injuries in Train, PLA]

[Text] The rats were given fluoride 20 mg/kg for 14 days through a gastrointestinal tube, body weight growth depressed obviously, the ratio of the liver and kidney weight to body weight increased significantly, hemoglobin concentration dropped and morphology and metabolism of collagen all became abnormal. All these effects can be antagonised by giving calcium (100 mg/kg), magnesium 100 mg/kg or calcium and magnesium combined (50 mg/kg each). When Ca and Mg is given combined, the antagonizing effect is even better.

Inhibition of Eight Natural Foods on Mutagenic Effect by Aflatoxin B₁ and Extracts of Fungi

40091017B Beijing ZHONGHUA YUFANG YIXUE ZAZHI [CHINESE JOURNAL OF PREVENTIVE MEDICINE] in Chinese Vol 26 No 2, Mar 92 pp 83-85

[English abstract of article by Ruan Cuicai [7086 5488 2088], Liang Yuan [4731 6678], et al., of the Guangxi Cancer Institute, Nanning]

[Text] Eight kinds of natural food were tested for their anti-mutagenic activities on AFB₁, metabolic extracts of *A. versicolor* and *A. ochraceus* which induced mutagenic activity in TA 98 and TA 100 mutants. The tested substances were extracted repeatedly with acetone. The revertance induced by AFB₁, metabolic extracts of *A. versicolor*

and *A. ochraceus* were significantly decreased when the food was added into the medium. The results showed that the eight kinds of food had different degrees of anti-mutagenic effect in vitro, suggesting that anti-mutagenic substances were present in the natural food. It is considered that the food may be practically valuable in the chemo-prophylaxis of liver cancer.

Effects of β -Agkistrodotoxin on Synaptic Transmission in Toad Sympathetic Ganglia

40091017C Shanghai SHENGLI XUEBAO [ACTA PHYSIOLOGICA SINICA] in Chinese Vol 44 No 2, 1992 pp 149-154

[English abstract of article by Jiang Xiaoting [5592 2556 1250] and Li Wande [2621 8001 1795] of the Cell Electrophysiology Laboratory, Wannan Medical College, Wuhu, and Xu Ke [1776 4430] and Zhang Jingkan [1728 2529 1660] of the Shanghai Institute of Physiology, Chinese Academy of Sciences, Shanghai]

[Text] The effects of β -agkistrodotoxin (β -AgTX) on synaptic transmission of the toad sympathetic ganglia were investigated by intracellular recording techniques. Superfusion of β -AgTX (30 μ g/ml, 5-15 min) reversibly inhibited the cholinergic fast excitatory postsynaptic potential (f-EPSP, $n = 16$) and the fast components of acetylcholine (ACh) potential induced by micropressure administration of ACh ($n = 24$). Comparison of β -AgTX effect in the same cell group showed significantly different inhibition rates on f-EPSP (77.2 plus or minus 27.7 percent) and ACh potential (25.5 plus or minus 17.5 percent) ($n = 6$, $P < 0.01$, F test). During application of β -AgTX (30 or 50 μ g/ml) for 15-30 min, no detectable change was found in non-cholinergic late slow EPSPs ($n = 22$). The results suggest that β -AgTX selectively inhibits the cholinergic transmission of the toad sympathetic ganglia by both presynaptic and postsynaptic mechanism.

Screening and Distinguishing Heavy Chain Variable Region Genes of McAb Against Encephalitis Type B Virus

40091017D Beijing YICHUAN XUEBAO [ACTA GENETICA SINICA] in Chinese Vol 19 No 2, Apr 92 pp 169-176

[English abstract of article by Huang Hualiang [7806 5478 4731] and Gui Jin [2710 6651] of the Institute of Genetics, Academia Sinica, Beijing and Chen Boquan [7115 0130 2938] and Ye Qunrui [0673 5028 3843] of the Institute of Virology, Chinese Academy of Preventive Medicine, Beijing, and Yang Zhixing [2799 1807 5281] of the Institute of Applied Microbiology, Academy of Heilongjiang Province, Harbin; this project was supported by the 863 Plan]

[Text] In order to prepare human-mouse chimeric antibody against encephalitis type B virus, hybridoma 51-8 cells secreting monoclonal antibody against the virus were used as material for isolating heavy-chain variable region gene of the McAb. High molecular weight DNA of the hybridoma cell was partially digested by *Bam*HI, and then constructed a gene library containing 2×10^7 pfu with

λ EMBL-3 as vector. With cDNA of heavy-chain variable region of the monoclonal antibody as probe, nine positive plaques were screened from 360,000 plaques, which have been proven that they contained a fragment of heavy-chain variable region genes by dot hybridization and Southern hybridization. Four recombinants among the nine positive plaques were further distinguished with J_{11} probe containing J_3 , J_4 and heavy-chain enhancer. After cutting by *EcoRI*, there was a 3.8 kb fragment in three recombinants as similar to that in liver cell and Sp2/0 cell, but not in the fourth recombinant (λ 8a4) which contained a 4.5 kb fragment that did not present in liver cell and Sp2/0 cell. The results showed that the inserts in former 3 recombinants were non-rearranged fragment of heavy-chain variable region genes, but the insert in λ 8a4 contained a rearranged functional variable region gene. The 4.5 kb fragment could not be hybridized with a probe containing J_1 and J_2 , but contained V_H , J_3 or/and J_4 and enhancer, that further proved it was a functional variable region gene. Therefore, the 4.5 kb fragment was isolated and subcloned in pUC 19, and its physical map was made. The results lay a foundation for constructing a human-mouse chimeric heavy-chain gene of the antibody against encephalitis type B virus.

Expression and Distribution of Catechol 2,3-Dioxygenase in *Escherichia coli*

40091017E Beijing YICHUAN XUEBAO [ACTA GENETICA SINICA] in Chinese Vol 19 No 2, Apr 92 pp 177-185

[English abstract of article by Xia Dongxiang [1115 2639 5046] of the Institute of Biotechnology, Academy of Military Medical Sciences, Beijing, Zeng Lun [2582 0178] of the Lanzhou Institute of Biological Products, Zheng Zhaoxin [6774 0340 9515] of the Fudan University and Wang Meixian [3076 5019 0341] of the Fourth Military Medical University, Xian]

[Text] A series of new plasmids containing *xyIE* gene was constructed based on the shuttle plasmid pTG 402 between *E. coli* and *B. subtilis*. The expressed *xyIE* gene product catechol 2,3-dioxygenase ($CatO_2ase$) was measured for its output and distribution, and analysed for its structural hydrophobicity and hydrophilicity. It was demonstrated that the output of $CatO_2ase$ was relative to plasmids, host cells, culture time and with or without induction. The enzyme didn't have features of excretional proteins and was mostly distributed inside the cells though a little could be detected in culture medium. It can be used as a selective marker, indicator and monitor in the study of genetic engineering. This research also provides a scientific basis for eliminating pollution of aromatic hydrocarbon compounds with genetic engineering bacteria.

Effect of Ribosome Binding Site Sequence on the Expression Level of *HBcAg* in *E. coli*

40091017F Beijing YICHUAN XUEBAO [ACTA GENETICA SINICA] in Chinese Vol 19 No 2, Apr 92 pp 186-191

[English abstract of article by Li Man [2621 3341] and Ma Xiankai [7456 6343 0418] of the Institute of Basic Medical Sciences, Academy of Military Medical Sciences, Beijing]

[Text] The recombinant (pKL series) Plasmids showing different levels of *HBcAg* antigenicity in ELISA were constructed by inserting the *HBcAg* gene which was randomly deleted at the non-coding region by *Bal-31* exonuclease into plasmid vector pKK223-3 containing tac promoter and SD sequence. SDS-PAGE and Western blot experiments indicated that molecular weight of the *HBcAg* protein generated by these positive clones was 21000D. Three plasmids with high, mode-rate and low *HBcAg* expression level were sequenced and the distance between SD sequence and *HBcAg* gene ATG codon was 12, 13 and 19 bp respectively. Computer analysis of secondary structure of the ribosome binding sites on RNA transcripts also revealed energy and structure differences between the low and high level expression plasmids, suggesting the importance of this distance and the mRNA structure to gene expression.

Structural Analysis of Polyhedrin Gene in Buzura Supperissaria Nuclear Polyhedrosis Virus Genome

40091017G Beijing WEISHENGWU XUEBAO [ACTA MICROBIOLOGICA SINICA] in Chinese Vol 32 No 2, Apr 92 pp 85-90

[English abstract of article by Qi Yipeng [7871 5030 7720], Zhang Shengjia [1728 3932 1367], et al., of the Department of Virology, Wuhan University, Wuhan]

[Text] The polyhedrin gene (*ocu*) of Buzura supperissaria nuclear polyhedrosis virus (Bs-NPV) was mapped on BamHI-H fragment and was constructed by XhoI, SmaI, HindIII, PstI and its 646 bp on both ends were sequenced by Sanger ddNTP chain-termination method. The typical properties of baculovirus *ocu* genes was found on 5' end of BsNPV *ocu* gene, which are ATG start region, promoter region (14 bp conservative sequences), TATA box and CATA box, etc. The unique XhoI site, which will be the inserting site for transfer vector constructed by BsNPV *ocu* gene, is mapped on 15 bp upstream of ATG. Specific 5 boxes that are CGAGC sequences are observed on the gene. The important function in high expression of the gene is discussed.

Virulence and Variation in Double-Stranded RNA From Isolates of *Rhizoctonia Solani*

40091017H Beijing WEISHENGWU XUEBAO [ACTA MICROBIOLOGICA SINICA] in Chinese Vol 32 No 2, Apr 92 pp 91-98

[English abstract of article by Zhang Jianbing [1728 0494 0393], Liang Pingyan [2733 1627 1750] of the Institute of Microbiology, Academia Sinica, Beijing]

[Text] *Rhizoctonia solani* is an important pathogen which can infect more than 100 crops. Detection of dsRNA in 18 isolates of *Rhizoctonia solani* isolated from cotton seedlings in North China was carried on and the virulence of these

isolates were compared. Results show: (1) The dsRNA occurred in *R. solani* with a high frequency (16/18). (2) The electrophoresis patterns of dsRNA from isolates of different geographical sources were varied in molecular weight of 0.93×10^6 - 4.8×10^6 and segment number of 1-8. (3) The resemblance of dsRNA segments in isolates collected from the same field suggested that the dsRNA transmission occurred frequently in natural condition. (4) Using [γ - 32 P] ATP end-labeled dsRNA from BUA-2 as a probe, dot blot analyses were made with 16 isolates dsRNA, in which the BAU-2 dsRNA showed a strong homology with that from BAU-2, BAU-3, HBS-5, all of three isolates were hypovirulent or middle virulent isolates. Northern transfer hybridization indicated that the sequence homology between these dsRNA was of 1.15×10^6 segment. (5) Using the linear *Penicillium chrysogenum* virus dsRNA as control, denatured dsRNA electrophoresis tests showed a lower electrophoretic migration of dsRNA from BAU-2 and BAU-3 and thus suggested the presence of circular structure dsRNA in *Rhizoctonia solani*.

Cloning and Expression of Coat Protein Gene of Turnip Mosaic Virus

400910171 Beijing WEISHENGWU XUEBAO [ACTA MICROBIOLOGICA SINICA] in Chinese Vol 32 No 2, Apr 92 pp 145-147

[English abstract of article by Qiu Bingsheng [6726 1629 3932], Wang Jinfang [3769 2516 5364], et al., of the Institute of Microbiology, Academia Sinica, Beijing]

[Text] Turnip mosaic virus (TuMV), a member of the polyvirus group, and considered to be the main virus that cause severe disease of crucifer plants, such as *Brassica campestris*, *B. pekinensis*, *Raphanus sativus*, etc. The RNA was extracted from TuMV, purified by differential centrifugation and CsSO₄ density gradient centrifugation, using oligo-dT as a primer to synthesize cDNA, which was then cloned into vector plasmid pUC19. It has been shown by immunological screening and Western Blot analysis that the No. 30 clone expressed the coat protein gene product. The sequence analysis of coat protein gene is in progress.

**Sino-German Minisupercomputer Prototype
Passes Acceptance Check**

92P60391D Beijing JISUANJI SHIJIE [CHINA
COMPUTERWORLD] in Chinese No 28, 15 Jul 92 p 1

[Article by Xin Zhi [2946 0037]: "China, Germany Jointly
Complete Major Natural Science Foundation Project"]

[Summary] A "new computer system supporting abstract data types" (i.e., the Starlet-II minisupercomputer prototype) jointly completed by 10 scientists and engineers from Shanghai Jiaotong University and Germany's Berlin New Computer Systems Research Center recently passed the expert acceptance check organized by the National Natural Science Foundation (NSFC), which financially supported the Chinese side of the project; German participation was supported by a grant from the Volkswagen Foundation. The experts noted that this minisupercomputer prototype, with a 33 MHz master clock speed, a peak performance of 66 MFLOPS (double-precision), and a sustained performance of 10 MFLOPS (double-precision), meets late-eighties international standards for foreign-made products. The Starlet-II incorporates high-speed address flow generators and a high-speed parallel memory consisting of high-speed serial-port video memory chips. The experts have appraised the MODULA-S parallel language, oriented toward parallel array representation, and its compiler design as being at the worldwide state-of-the-art in terms of parallelization.

**Beijing Hitachi Huasheng Information Systems
Ltd. Joint Venture Founded**

92P60365A Beijing JISUANJI SHIJIE [CHINA
COMPUTERWORLD] in Chinese No 25,
24 Jun 92 p 1

[Article by Tang Baoxing [3282 1405 5281]: "Sino-
Japanese Joint Venture Established: Beijing Hitachi Hua-
sheng Information Systems Ltd."]

[Summary] Japan's Hitachi Ltd. and the China Computer Systems Engineering Co. (MMEI's Institute 6) have formed a joint venture—Beijing Hitachi Huasheng [5478 0524] Information Systems Ltd.—the contract for which was signed on 12 June in Beijing. This new joint venture, which will develop computer software and information systems for the domestic and overseas markets, has registered capital of US\$380,000, of which 51 percent will be supplied by the Japanese side and 49 percent by the Chinese side. Hitachi will assume general management responsibility for this joint venture, which has a term of 15 years.

**World's First Intelligent English-Chinese
Machine Translation System Certified**

92P60365B Beijing KEJI RIBAO [SCIENCE AND
TECHNOLOGY DAILY] in Chinese 26 Jun 92 p 1

[Article by Wang Jianmin [3769 1017 2404]: "China
Develops Intelligent English-Chinese Machine Translation
System"]

[Summary] The "IMT/EC-863" intelligent English-
Chinese machine translation system—the world's first
such system—passed the appraisal organized by the State

S&T Commission in Beijing a few days ago [22 June]. This system, jointly developed over a 7-year period by a group of seven domestic organizations—the CAS Computing Institute (whose Dr. Chen Zhaoxiong [7115 5128 7160] was chief developer and designer), China S&T Information Institute, China Kejian [4430 0256] Co., Beijing Science & Technology University, Beijing Lianda [5114 1129] Institute of Automation Engineering, PLA Logistics Institute, and PLA General Staff Institute 61—was also a State 863 Plan key project. The IMT/EC-863, now at a utilitarian stage, has a basic English vocabulary of 45,000 words, a corresponding Chinese vocabulary of 250,000 words, 1,500 general-purpose rules, and 150,000 special rules and idioms. The system, which uses the C programming language, runs on the Sun SPARCstation series of workstations or on an IBM PC microcomputer and compatibles. In a test of 100 English sentences input by members of the appraisal committee, the system demonstrated an average accuracy of 83 percent.

Unveiled at the "91 Hong Kong Computer Software Exposition," at which over 30 foreign firms expressed interest in becoming sales representatives and at which almost 10 companies from the United States, Canada, and Hong Kong expressed hopes to become investment partners for further development, this system will be used at the Daya Bay Nuclear Power Plant for translating English-language documents into Chinese. Some of the applications software and the "Kuai yi tong—863" ["Fast translation general-purpose—863"] pocket-size model jointly developed with a Hong Kong firm should be on the market by September of this year.

**NMS Neural Network Simulation Software
Package Certified**

92P60391A Beijing JISUANJI SHIJIE [CHINA
COMPUTERWORLD] in Chinese No 27, 8 Jul 92 p 2

[Article by Li Yucheng [2621 3768 2052] and Zhou Hong
[0719 5725]: "NMS Neural Network Simulation Software
Package Passes Appraisal"]

[Summary] The "NMS neural network simulation software package" developed by a Southeast University research team led by Prof. Wei Yu [7279 6877] as part of an 863 Plan high-tech project entitled "Research on Artificial Neural Network Models Based on Molecular Devices" recently passed expert technical appraisal in Nanjing. The NMS software package, intended as a neural network research and teaching aid, consists of two main modules: one for artificial neural network simulation and one for biological neuron element computational characteristics simulation. In comparison with comparable foreign-made products, this menu-driven software package has a novel graphics interface and novel interactive training routines.

**Qinghua University Firm Markets ITbase
Software**

92P60391F Beijing JISUANJI SHIJIE [CHINA
COMPUTERWORLD] in Chinese No 29, 22 Jul 92 p 3

[Article by Zhuang Xin [8369 2946]: "Qinghua's San Ai
Co. Markets ITbase Software"]

[Summary] ITbase general-purpose text/graphics DBMS, recently developed by Qinghua University's San Ai [0005 5337] Computer Systems Co., will be on the market this month [i.e., July 1992]. While being fully compatible with dBASE and Foxbase, ITbase is the first general-purpose text/graphics DBMS overcoming the text-but-no-graphics limitation of those two [foreign-made] general-purpose textual DBMSs. The traditional-Chinese-character and English-language versions of ITbase should also hit the market this year.

Xinxin Co. Signs US\$1.1 Million Software Contract With Taiwan Science Museum

92P60391B Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 27, 8 Jul 92 p 1

[Article by Liu Keli [0491 0344 7787]: "Xinxin Software Co. Gets US\$1.10 Million Taiwan Contract"; cf. earlier report in JPRS-CST-92-012, 18 Jun 92 p 58]

[Summary] On 12 June, representatives from Shenzhen's Xinxin [2450 2946] Software Industries Ltd. and from the Taiwan Natural Science Museum formally signed a US\$1.10 million (HK\$8.5 million) contract. Xinxin will supply the Taiwan museum with multimedia demonstration software systems in the largest project to date involving mainland provision of software to Taiwan. The entire software system consists of nine subsystems and 21 demonstration training routines to be installed in three main exhibition halls (total of nine rooms) at the museum. Joint debugging and trial operation is to be conducted in December this year.

Names of First 10 Registered Software Packages Announced

92P60391C Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 27, 8 Jul 92 p 1

[Article by Han Yun [7281 0061]: "Vigorous Efforts To Implement Software Protection: First 10 Software Packages by New Registration Rules Are Announced"]

[Summary] On 16 June [1992], the first 10 domestic software products to be given computer software copyright registration certificates were announced. Guo Chengzhong [6753 6134 1813], director of MMEI's Computer Software

Registration Office, commented that software intellectual property rights protection is vitally important to the development of the nation's software industry and to international cooperation. These first 10 products, awarded certificates #920001-920010, respectively, are: the Beijing Stone Group's Stone English-Chinese Electronics Dictionary V1.0, Xiao Shuiqing's Xiao Easy-to-Learn-Code Fast Chinese Text Input Software V2.0, Liu Xi's 123 Accounts Processing Software V1.0, the "Gold" Finance System VHD1.0 jointly developed by the Beijing Municipal Travel Vehicle Co.'s Accounting & Finance Department and Wang Jian, the China Computer Software & Technical Services Corp.'s "Yixing" English-Chinese Machine Translation Software V1.0, Beijing Stone Group's Stone High-Level Computer Typesetting Machine Software V4.2, Beijing Wang Ma Computer Corp.'s Wang Ma 5.1 Chinese/English System V5.1, Beijing Wang Ma Computer Corp.'s Wang Ma 480 Tabletop Office System V1.0, the Beijing (Haidian Zone) Weihong Computer Software Institute's UNFOX2.1 Reverse Compiler Doctor V2.1, and Beijing Wang Ma Computer Corp.'s Wang Ma 480 Tabletop Office System V2.0.

Nation Becomes World's Second Largest Producer of STD Industrial Control Computers

92P60391E Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 28, 15 Jul 92 p 1

[Article by Sheng Shi [4141 0013] and Liu Keli [0491 0344 7787]: "Nation Becomes Second Largest Producer of STD Industrial Control Computers"]

[Summary] It has been learned from the '92 Modern Industrial Control Technology Applications Exchange concluded on 20 June in Beijing that the output value of domestically made STD bus industrial control computers has broken through the 100 million yuan barrier, making China the world's second largest producer—the United States being first—of such computers. Since they were first made domestically in 1984, these computers have become increasingly popular, with output value reaching 50 million yuan in 1988, 60 million yuan in 1989, and 70 million yuan in 1990, before breaking through the 100 million yuan mark in 1991. STD bus industrial control computers are used in the machinery, electronics, metallurgical, petroleum, chemical engineering, power, and building materials industries, among others.

Critical CIMS Subsystem Technologies Certified
92P60392A Beijing JISUANJI SHIJIE [CHINA
COMPUTERWORLD] in Chinese No 27, 8 Jul 92 p 2

[Article by Ke Wen [2688 2429]: "Shanghai Jiaotong University Develops Critical Subsystem for Computer Integrated Manufacturing Systems"]

[Summary] The "industrial control computer LAN technology and protocol implementation" project completed by researchers in the Network and Distributed Processing Group in the Computer Department at Shanghai Jiaotong University and funded by a grant from the Municipal S&T Development Foundation recently passed appraisal in

Shanghai. This computer integrated manufacturing systems (CIMS) critical subsystem technology, applicable to industrial firms of all sizes and designed for PC XT/286/486 computers, encompasses development of an intelligent network card, implementation of a lower-layer protocol based on the 10 Mbps IEEE 802.4 standard [i.e., token bus topology] and of a Mini-MAP comprehensive applications high-layer protocol (involving 9 man years of effort and occupying 33,000 lines of code written in the C programming language), and development of China's first independently copyrighted Mini-MAP-C software. Mini-MAP-C was used in the CIM-NET industrial simulation network, an "863" Plan high-tech project realizing a savings of 60,000 yuan.

512-Bit Infrared CCD Developed by Institute 44

92P60393F Beijing ZHONGGUO DIANZI BAO
[CHINA ELECTRONICS NEWS] in Chinese 20 Jul 92
p 2

[Article by Yu Ruming [0151 3067 2494]: "512-Bit Infrared CCD Device Developed"]

[Summary] A 3-5-micron-wavelength 512-bit infrared charge-coupled device (CCD) developed by MMEI's Institute 44 (located in Yongchuan County, Sichuan) recently passed product design finalization. This backside-illuminated IR device, whose detection principle is internal optoelectronic emission, has a double channel shifted output structure, and consists of three main components: the detection region, including a 512-bit platinum silicide Schottky barrier diode as the IR detecting element; a transfer region made up of a barrier gate, storage gate, transfer gate and a double row of CCD shift registers distributed along the two sides of the detection region; and an I/O region composed of an input diode and a floating diffusion amplifier. Device detectivity is 3×10^{10} cm-Hz^{1/2}/W, nonuniformity S is less than or equal to 8 percent, and operating frequency is 2.5 MHz—main performance parameters in the leading position domestically. Applications include space detection, research, medicine, IR guidance, night vision, and IR thermal imaging.

State Commission Approves Funds To Build CCD R&D Line at Institute 44

92P60393A Beijing ZHONGGUO DIANZI BAO
[CHINA ELECTRONICS NEWS] in Chinese 6 Jul 92
p 3

[Article by Yu Ruming [0151 3067 2494]: "State Approves Construction of CCD Research and Development Line at Institute 44"]

[Summary] In order to provide facilities for four modernization projects at MMEI's Institute 44, the State Planning Commission has approved funds for construction of a charge-coupled device (CCD) research and development line at the institute, which specializes in semiconductor light-emitting devices and optical detectors. The new line will permit the institute to annually develop four to six new kinds of high-quality linear array CCDs for high-speed FAX machines, image processors, non-contact measurement instruments and the like, as well as several new varieties of B&W surface array CCDs and color CCDs for broadcast TV, industrial monitoring, cameras, and similar purposes. The focus of the new construction will be on device commercialization, especially export-oriented.

Additional Details on GaAs/AlGaAs Multi-Quantum-Well IR Detector

92P60402A Shanghai HONGWAI YU HAOMIBO
XUEBAO [JOURNAL OF INFRARED AND
MILLIMETER WAVES] in Chinese Vol 11 No 2,
Apr 92 p 102

[Article by He Chunfan [0149 2504 5672] of the CAS Institute of Semiconductors: "Domestically Fabricated Quantum-Well Infrared Detector Passes Appraisal"; cf. earlier report in JPRS-CST-92-012, 18 Jun 92 p 63]

[Summary] The GaAs/AlGaAs multi-quantum-well (MQW) IR detector jointly developed over a 2-year period by the CAS State Laboratory for Surface Physics and the Ministry of Aerospace Industry's Shanghai Institute 803 passed CAS-level appraisal on 29 January 1992. The project was aided by basic research at Fudan University and Nanjing University on growth of Ge/Si superlattice quantum-well materials, and was guided by internationally famous researcher Prof. Huang Kun [7806 2492] of the CAS Institute of Semiconductors. In a project begun in 1989 and achieving first success in September 1991, the CAS researchers developed a detector with the following performance parameters as measured by the appraisal experts: peak wavelength is 9.2 μ m, operating temperature is 77K, peak voltage responsivity is 9.7×10^5 V/W, wavelength bandwidth is 0.5 μ m, black-body detectivity at 500K is 1.46×10^9 cm-Hz^{1/2}/W, and peak detectivity is 6.0×10^{10} cm-Hz^{1/2}/W—values which match the international state-of-the-art. This breakthrough provides a major boost to domestic development of MQW long-wavelength IR focal plane arrays.

Modified Multivalued Neural Network Model, Optical Implementation

92P60404A Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 12 No 5,
May 92 pp 457-461

[Article by Zhu Weili [2612 0251 0448] of the Dept. of Physics, Central Institute of Nationalities, Beijing 100081 and Chen Yansong [7115 1484 2646] of the CAS Institute of Physics, Beijing 100080: "Modified Multivalued Neural Network Model and Its Optical Implementation," supported by grants from NSFC and TWASRG MP890-035; MS received 7 Jan 91, revised 13 Aug 91]

[Abstract] A modified multivalued neural network model—the Positive Complementary-State Model (PCM)—and its optical implementation are presented. The optical system with spatial light modulator (SLM) PROM is designed to implement associative memory. The results of computer simulation and experiment indicate that neural-network searching identification is improved and storage capacity increased, when compared to the Hopfield model (HM) and a normalized model (CM). Figure 1 below shows a schematic for the PCM's optical implementation, while Figure 2 (not reproduced) shows a photo of the equipment arrangement. One table shows searching results produced by computer simulation and by optical neural network for the PCM, HM, and CM models.

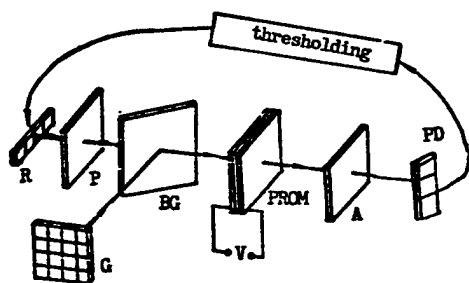


Figure 1. Schematic of Optical System for Implementing Neural Network

Key: R - red LED array; G - green LED array; P - polarizer; A - analyzer; BG - beam splitter; V - DC electrical power

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Continuous Large-Area Optical Lithography Unit Developed

92P60393B Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 8 Jul 92 p 1

[Article by Fang Xiliang [2455 6932 5328]: "Continuous Large-Area Optical Lithography Machine Unveiled"]

[Summary] The Nanguang [0589 0342] Plant recently completed development and debugging of the model H94-23 continuous large-area optical lithography machine, designed for continuous exposure of rectangular wafers. Maximum optical lithography area is 280 mm x 100 mm, and optical lithography accuracy is 0.25 micron. This new highly reliable high-tech unit consists of 12 major components, including the exposure head, a binocular separation field of view, microscope illumination, a vernier platform, the housing, and the electronic control rack.

Large-Area UV Lithography Unit Developed for FPD R&D

92P60393C Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 13 Jul 92 p 1

[Article by Cui Yachao [1508 0068 6389]: "Nation Develops Large-Area Ultraviolet Optical Lithography Machine: Suitable for Flat Panel Display Technology Research, Production"]

[Summary] In a 4-year-plus effort, the CAS Changchun Institute of Optics and Fine Mechanics has developed a 16-inch-diagonal ultraviolet optical lithography machine—a key piece of equipment for research and production of large-area flat panel displays (FPDs). China has thus become the world's third nation—the first being the United States and Japan—able to domestically manufacture this equipment. Exposure mobility is 25 inches, optical lithography linear accuracy is under 3 microns, alignment precision is 2.5 microns, exposure nonuniformity is under ± 3 percent, and radiation instability is ± 1 percent, meeting late eighties international standards. This new equipment, patented by the State, has been successfully trial-operated at MMEI's Institute 55, the Beijing Electronic Devices Plant, and the Weihai Beiyang Electrical Equipment Group.

Thin-Film Electroluminescent FPD Certified

92P60393D Beijing RENMIN RIBAO in Chinese 15 Jul 92 p 3

[Article by Jin Rendu [6855 0088 1717]: "New Light-Emitting Display Developed"]

[Summary] The thin-film electroluminescent flat panel display (FPD) developed by Shaanxi Machinery Institute Associate Professor Chai Tianen [2693 1131 1869] recently passed expert appraisal in Xian. This new low-voltage, long-life, high-efficiency FPD, fabricated on glass, has an emitted-light brightness of over 90 nits [1 nit = 1 candle per square meter] and can display numbers, characters, and graphics. Targeted applications include transportation, advertising, computer terminals, military command systems, and military aircraft cockpits.

Enamel AC Electroluminescent Flat Panel Display Certified

92P60366A Beijing ZHONGGUO KEXUE BAO [CHINESE SCIENCE NEWS] in Chinese 26 Jun 92 p 2

[Article by Shi Mingshan [4258 2494 1472]: "Changchun Institute Develops Enamel AC Electroluminescent Display"]

[Summary] A new type of light-emitting device—an enamel alternating-current electroluminescent flat panel display—developed by the CAS Changchun Institute of Physics recently passed expert appraisal in Changchun. In developing this new display, the Changchun Institute had to overcome a number of technical difficulties, including optimization of the enamel dielectric manufacturing process. Institute researchers carried out over 100 experiments and tests in the 1-year-plus development period.

Development of FEL Small-Period Wiggler

92FE0614A Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 41 No 3, Mar 92 pp 442-447

[Article by Feng Bibo [1409 4310 3134], Wang Mingchang [3769 2494 1603], Wang Zhijiang [3769 0037 3068], Lu Zaitong [7120 6528 6639], Zhang Lifan [1728 4539 5358], and Feng Chengshi [7458 6134 1102] of the Shanghai Institute of Optics and Fine Mechanics, the Chinese Academy of Sciences: "Development of a Novel Small-Period Wiggler"; MS received 1 Mar 91]

[Text] Abstract

A novel small-period wiggler is presented. It is constructed in a bifilar helix configuration with a ferro-core to produce a circularly polarized magnetic field. The magnetic field of a 100-mm-long prototype wiggler with a 10-mm period was measured. The transverse magnetic field is as high as 1 KG. With an existing accelerator, which has an accelerating voltage of 400-500 keV, the design of a 190 GHz small-period FEL wiggler is proposed.

I. Introduction

A small-period (1-10 mm) wiggler has significant advantages in FEL (free electron laser) research. The FEL output wavelength is related to the wiggler period and the energy of the electron beam (e-beam) as follows:

$$\lambda \approx \lambda_w / 2\gamma^2 \quad (1)$$

where λ and λ_w are the laser output wavelength and wiggler period, respectively, and γ is the electron energy factor. At a given laser wavelength, the FEL imposes a lower electron energy requirement with a small-period wiggler. Hence, the advantages of a small-period wiggler are as follows: It lowers the electron energy requirement, which also reduces the need for radiation shielding. Consequently, the system is more compact and costs less. On the other hand, since the wiggler period is reduced, the wiggler's magnetic field decays exponentially. In order to obtain a large magnetic field, it is necessary to reduce the wiggler gap. Hence, the e-beam current is limited. Consequently, the FEL gain and power are also lowered.

One way to downsize an FEL is to develop a small-period wiggler FEL, which may be used as a high-power millimeter-wave source, extremely useful in basic scientific research and in military applications. It may be used in studies such as magnetically confined plasma excited by electron cyclotron resonance heating (ECRH), non-linear spectroscopy, energy-conversion mechanisms in molecules, solids and liquids, and other transient effects. In military applications, it may be used in research on millimeter-wave radar, communications, and electronic warfare, e.g., as a blinding coherent emission source and counter-stealth target-forming technique. The development of tunable short-period millimeter-wave wigglers just meets these needs.

There have been a number of published reports on small-period wiggler designs and experiments.¹ A small-period wiggler in a wafer configuration, with $\lambda_w = 5-10$ mm and $B_y = 1-2$ KG, was developed at the University of Maryland.^{2,3} On this basis, NRL (Naval Research Laboratory) developed a wiggler which is similar in construction to the University of Maryland wiggler. It is called the reduced edge-effect linear wiggler and its magnetic field reaches 2-4 KG.⁴ At MIT [Massachusetts Institute of Technology], a small electromagnetic wiggler similar to a video camera head was developed by winding a fine wire around a C-shaped Fe-Si coil.⁵ In addition, a superconducting wiggler was developed by LANL (Los Alamos National Laboratory) and a small-period permanent magnet wiggler was developed by LLNL (Lawrence Livermore National Laboratory) and UCSB (University of California at Santa Barbara).^{1,6} In 1984, we developed a 3-m-long permanent magnet wiggler with a period of 24 mm and magnetic field of 3 KG.⁷

In research on small-period wiggler FELs, a linearly polarized wiggler is often used abroad. This type of structure has a very small gap between the magnetic poles which is detrimental to the transport of the e-beam. It usually requires that the e-beam be in the form of a sheet which significantly limits the current and reduces the laser output. We have designed a novel small-period wiggler which is a bifilar helix in configuration with a ferro-core. It produces a circularly polarized periodic magnetic field. This kind of small-period wiggler FEL can use a high-current solid or hollow cylindrical e-beam. Hence, the laser output is significantly increased compared to that of other small-period FELs. In this paper, the structure and the magnetic field of this novel wiggler are discussed. Then, based on the wiggler magnetic field, a series of design parameters for the small-period wiggler FEL experiment is given.

II. Structure of the Small-Period Wiggler and Its Magnetic Field

Figure 1 shows the structure of the small-period wiggler. It is made of a bifilar-helix with a ferro-core. It is similar in structure to a bifilar-helix wiggler and the helix is made of two sets of copper ribbons wound around a soft ferro-core. Insulation between the ferro-core and the copper is provided by an insulating paint or a thin film. The two sets of copper ribbons are connected on one end and opposite currents are applied to the other end. In Figure 1, λ_w is the period of the wiggler; R and r are the outer and inner radius of the helix, respectively; and h_1 and h_2 are the thicknesses of the copper ribbon and the soft ferro-core, respectively.

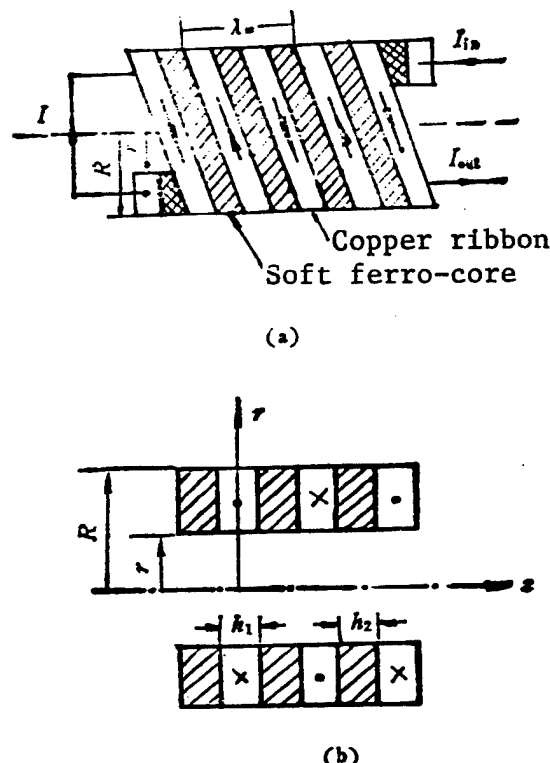


Figure 1. Schematic Diagram of the Bifilar-Helix Small-Period Wiggler

Without the ferro-core, when opposite currents are applied to the two sets of copper ribbons, a periodically varying circularly polarized magnetic field is generated inside the solenoid. The magnetic field can be approximately calculated as follows:⁸

$$\begin{aligned} B_r &= 2B_w \left[I_0(k_w r) - \frac{I_1(k_w r)}{k_w r} \right] \sin(\theta - k_w z); \\ B_\theta &= \frac{2B_w I_1(k_w r)}{k_w r} \cos(\theta - k_w z); \\ B_z &= -2B_w I_1(k_w r) \cos(\theta - k_w z), \end{aligned} \quad (2)$$

where B_w is the axial magnetic field in the transverse cross section:

$$B_w = \frac{8\pi I}{10\lambda_w} \left[\frac{2\pi r}{\lambda_w} k_0 \left(\frac{2\pi r}{\lambda_w} \right) - k_1 \left(\frac{2\pi r}{\lambda_w} \right) \right], \quad (3)$$

$k_w = 2\pi/\lambda_w$; I_0, I_1, k_0, k_1 are the zeroth-order and first-order deformed Bessel functions.

Near the axis (i.e., $r \approx 0$), the magnetic field is approximately

$$\begin{aligned} B_r &= B_w \sin(\theta - k_w z); \\ B_\theta &= B_w \cos(\theta - k_w z); \quad B_z = 0. \end{aligned} \quad (4)$$

From the above, we know that the transverse magnetic field strength of the bifilar-helix wiggler varies periodically as a function of the distance z . On the axis, the amplitude of the field remains constant.

With a ferro-core, the magnetic field inside the solenoid is significantly increased. Compared to the wiggler without a ferro-core, the magnetic field distribution is somewhat different; however, the periodic nature of the magnetic field does not change. Qualitatively, the field in the B_r direction is strengthened with the addition of a ferro-core.

III. Experimental Results

Figure 2 shows a picture of the ferro-core-based bifilar-helix small-period wiggler we have developed. The wiggler has a period $\lambda_w = 10$ mm, overall length of 100 mm and

total number of periods $N = 10$. The inner and outer radii of the helix are 10 mm and 20 mm, respectively; the thickness of the copper and the thickness of the ferro-core are both 2 mm; and the input and output resistance of the helix are 30 m Ω . The ferro-core is made of silicon steel and there is a thin insulating film between the copper ribbon and the ferro-core.

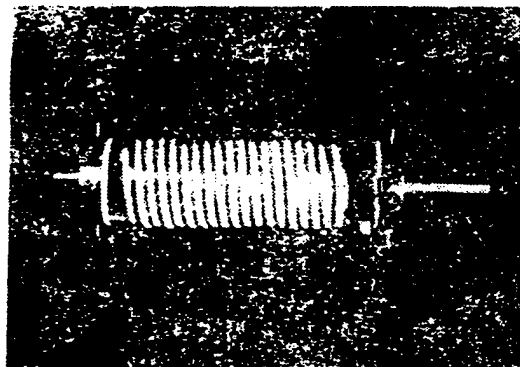


Figure 2. Photograph of the Small-Period Wiggler; period = 10 cm and length = 100 mm

The currents applied to the wiggler are provided by a series of capacitors. A voltage divider is used to measure the current in the discharge circuit. It was experimentally determined that the relation between the voltage across the capacitor and the peak current in the discharge circuit is $I \approx 13 U_0$. The differential signal of the wiggler (dB_w/dt) along the axis was measured using an induction coil developed in-house. By means of a Miller integrator, the transverse magnetic field was determined by this signal.

Figure 3 shows how the magnetic field versus time curve where the upper charging voltage limit of the capacitor is 500 V. Figure 3 also compares the situations with and without the ferro-core. Because of the ferro-core, the waveform varies more. The leading edge before reaching the peak is reduced to 0.086 ms with the ferro-core from 0.2 ms without the ferro-core. Furthermore, the peak appears smoother, which facilitates the FEL experiment. The pulse widths are both approximately 0.83 ms. The amplitude of the magnetic field is significantly increased, approximately by three-fold compared to that without a ferro-core.

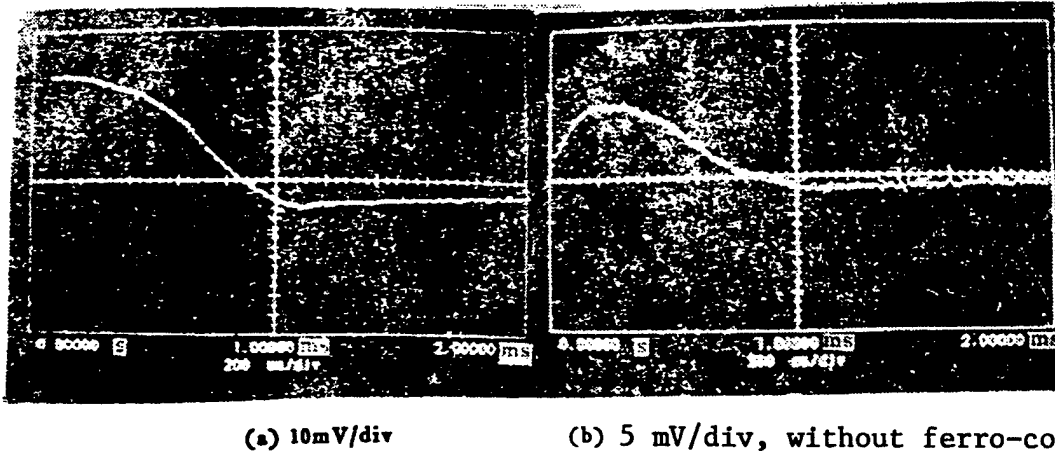


Figure 3. Small-Period Wiggler Magnetic Field vs. Time, With Ferro-Core, Capacitors Charged to 500 V

A series of experimental data points, as shown in Figure 4, was obtained by varying the charging voltage of the capacitor. The wiggler magnetic field may be varied by adjusting the charging voltage. The 1 kG magnetic field required by the FEL experiment is achievable.

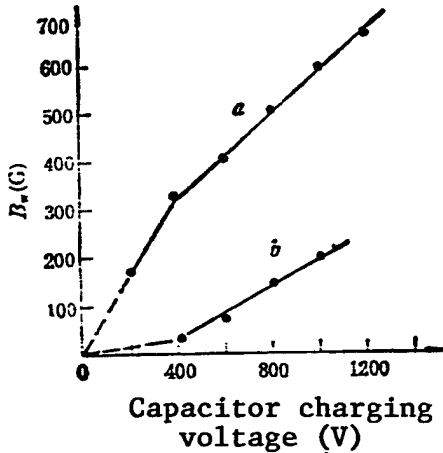


Figure 4. Wiggler Magnetic Field (Peak) B_w vs. Capacitor Charging Voltage; curve a is with a ferro-core, curve b is without a ferro-core.

By keeping the direction of the coil unchanged in the wiggler magnetic field and by moving the coil along its axis, the periodic variation of the wiggler magnetic field along the z axis was determined, as shown in Figure 5. The wiggler period is 10 mm and the charging voltage is 500 V.

IV. Design of Small-Period FEL

It is well known that the Raman FEL is a result of coupling between the waveguide mode and the negative energy space-charge wave in the electron plasma. Further, it follows the following equation:

$$\omega = (k + k_w)v_z - \omega_p/\gamma \approx (k + k_w)v_z \quad (5)$$

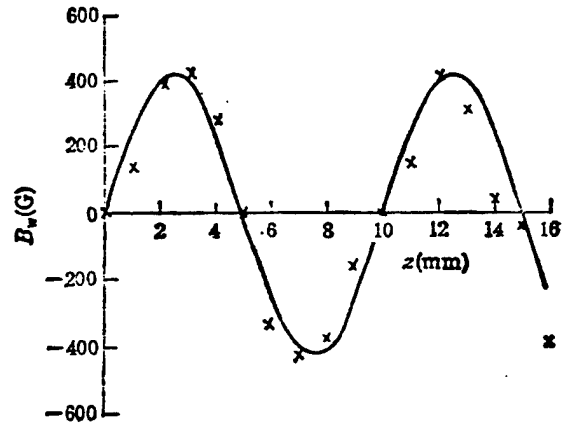


Figure 5. Magnetic Field B_w of a Small-Period Bifilar-Helix Wiggler Along the z-Axis; charging voltage = 500 V, x indicates measured points.

where ω_p is the frequency of the electron plasma, and ω and k are the frequency and wave number of the laser, respectively.

On the other hand, since the e-beam is transported in a waveguide, the dispersion relation of the electromagnetic wave must be corrected. The approximate result is:

$$\omega^2 - c^2k^2 = \omega_{\infty}^2 \quad (6)$$

where ω_{∞} is the cutoff frequency of the waveguide. When $\omega_p \ll \omega_{\infty}$, based on equations (5) and (6), the output frequency of the FEL is

$$\omega = k_w v_z \gamma^2 \left[1 \pm \beta_z \left(1 - \frac{\omega_{\infty}^2}{k_w^2 \beta_z^2 \gamma^2} \right)^{\frac{1}{2}} \right]. \quad (7)$$

Figure 6 shows how the output frequency varies as a function of the wiggler magnetic field B_w . The following

parameters were selected for the calculation shown in Figure 6: electron energy factor $\gamma = 2$, $\lambda_w = 10$ mm, and drift tube radius $r_g = 7.5$ mm. From Figure 6, when $B_w = 1$ kG, the output laser frequency is $f \approx 190$ GHz, i.e., $\lambda \approx 1.6$ mm.

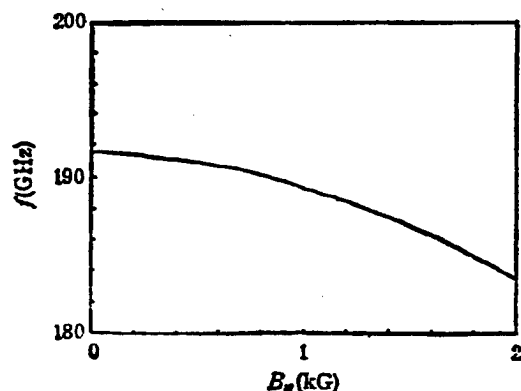


Figure 6. Output Frequency Versus Wiggler Magnetic Field B_w

electron energy factor $\gamma = 2$, $\lambda_w = 10$ mm, and drift tube radius $r_g = 7.5$ mm.

Theoretical analysis of a collective Raman FEL^{9,10} shows that the gain and efficiency of a Raman FEL without an applied guiding magnetic field are as follows:

$$(ImK)_{max} \approx \frac{1}{2} |\beta_{\perp}| (\omega_p k_w \gamma_s / \nu_s)^{\frac{1}{2}}$$

and

$$\eta = \omega_p / (\gamma^{\frac{1}{2}} \gamma_s c k_w). \quad (8)$$

With the parameters chosen for Figure 6, when $B_w = 1$ kG, the FEL has a gain of 0.11 cm^{-1} and an efficiency of approximately 9 percent.

The magnetic field generated by the bifilar-helix magnetic field increases with its radius. It also has a focusing effect on the e-beam. Furthermore, when an electron moves off the axis, it is subjected to the focusing effect of B_z . Hence, this kind of small-period FEL can be used in Raman FEL superradiation amplification experiments without an applied axial guiding magnetic field.

Table 1 shows a series of parameters for this novel wiggler design and the corresponding Raman FEL without an applied axial guiding magnetic field.

Table 1

Accelerator	Accelerating voltage V	500 keV
	Electron energy factor γ	1.98
	Beam current radius	3 mm
Wiggler parameter	Beam intensity	1 kA
	Pulse width	60 ns
	Outer radius R	20 mm
	Inner radius	9 mm
	Copper thickness h_1	2 mm
	Ferro-core thickness h_2	2 mm
	Period λ_w	10 mm
	Number of periods N	10
	Magnetic field strength B_w	1,000 G
	Calculated values	
	Output frequency f	190 GHz
	Gain $(ImK)_{max}$	0.11 cm^{-1}
	Efficiency η	9%

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Additional Details on Domestic 100J-Class KrF Excimer Laser

92P60372A Chengdu QIANG JIGUANG YU LIZI SHU
[HIGH POWER LASER AND PARTICLE BEAMS]
in Chinese Vol 4 No 2, May 92 p inside front cover

[Article by Gao Jinsi [7559 6511 1835]: "100-Joule-Class KrF Excimer Laser Passes Ministry-Level Appraisal"; cf. early reports in JPRS-CST-92-008, 30 Apr 92 pp 17-29, 70]

[Summary] The 100J-class KrF excimer laser developed by the China Research Institute of Atomic Energy Sciences passed ministry-level appraisal on 2 March 1992. Tracking worldwide developments since 1988, the research team overcame numerous obstacles such as physical/engineering design, accelerator improvements, large-area intense electron-beam generation/transmission, laser-medium energy deposition, laser dynamics simulation, and laser parametric diagnosis. This KrF excimer laser has an output energy of 106 J, a center wavelength of 248 nm, a wavelength distribution FWHM (full width at half maximum) of 0.5 nm, a laser pulse width of 80 ns, and an output power of 10^3 MW [i.e., 1 GW]—the first time such a value has been reached domestically and one that ranks in the world's forefront. Applications include industry, medicine, biology, and basic research (especially thermonuclear fuel compression and combustion and inertial confinement fusion).

Optical Properties of Oxide Coatings Prepared by Ion-Assisted Deposition

92P60372B Chengdu QIANG JIGUANG YU LIZI SHU
[HIGH POWER LASER AND PARTICLE BEAMS]
in Chinese Vol 4 No 2, May 92 pp 245-250

[Article by Tang Xuefei [3282 7185 7378] and Fan Zhengxiu [5400 2973 0208] of the CAS Shanghai Institute of Optics & Fine Mechanics (SIOFM), P.O. Box 800-211, Shanghai 201800: "Optical Properties of Oxide Thin Films Prepared by Ion-Assisted Deposition"; MS received 7 Jun 90, revised 4 Oct 91]

[Abstract] Effects of ion energy, ion current intensity, and ion species on refractive indices, optical absorptance, and laser-induced damage threshold (LIDT) of TiO_2 , ZrO_2 , and SiO_2 oxide coatings prepared by ion-assisted deposition (IAD) are investigated. The internal structure (vacuum chamber) of the 1-m-diameter film-deposition machine is shown in Figure 1 below, while Figure 2 below shows the absorption measurement system. An 8-cm-aperture Kaufman ion gun provides a 300-1,000 eV neutral ion beam. The laser used for the LIDT measurements is a 1.06 μm -wavelength, 10-ns-pulse-width YAG laser. Figures 3-7 [figures not reproduced] show the refractive index of TiO_2 films bombarded with O_2^+ as a function of ion energy, the refractive index of TiO_2 films bombarded with O_2^+ as a function of ion current density, the refractive index of TiO_2 films bombarded with different ions, the refractive index of ZrO_2 films bombarded with different ions, and the refractive index of SiO_2 films bombarded with an ion mixture ($\text{Ar}:\text{O}_2 = 7:3$), respectively. All four tables are reproduced below.

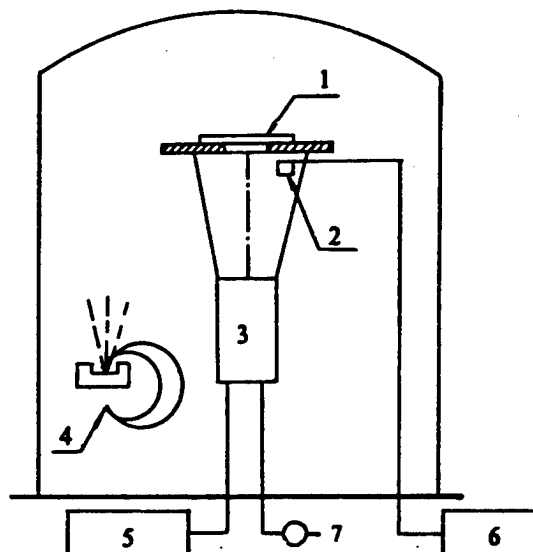


Figure 1. Configuration of Deposition System

Key: 1. Substrate 2. Faraday probe 3. Ion source 4. Electron gun 5. Ion gun power supply 6. Galvanometer 7. Inserted gas

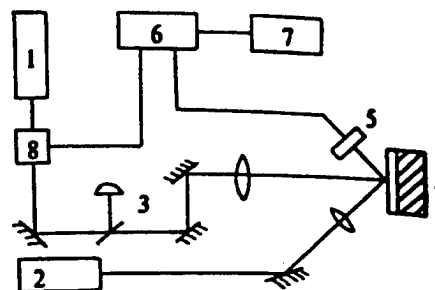


Figure 2. Configuration of Absorption Measurement System

Key: 1. Pump laser 2. Probe laser 3. Power monitor 4. Sample 5. Position sensor 6. Lock-in amplifier 7. Oscilloscope 8. A-O [acousto-optic] modulator

Table 1. Deposition Parameters

Material	TiO_2	ZrO_2	SiO_2
Deposition rate/(nm \cdot s $^{-1}$)	0.6-0.7	0.5	0.5
Substrate temperature/ $^{\circ}\text{C}$	50	50	50
Pressure of O_2 /Pa	1.2×10^2	2×10^{-2}	$<10^{-3}$
Optical thickness	$\lambda/4$	$\lambda/4$	$\lambda/4$

Table 2. Effect of Different Ion Bombardment on Absorbance of TiO₂ Coatings

Ion	Ion Energy/eV	Ion Current Density/($\mu\text{A} \cdot \text{cm}^{-2}$)	Extinction Coefficient
Ar	200	50	$>10^{-2}$
Ar:O ₂ , 7:3	300	50	9.0×10^{-3}
	500	50	3.0×10^{-2}
	500	100	6.4×10^{-2}
Ar:O ₂ , 3:7	300	50	2.8×10^{-4}
	400	50	3.8×10^{-4}
	500	50	4.0×10^{-4}
	600	50	3.5×10^{-4}
O ₂	300	50	2.8×10^{-4}
	400	50	3.4×10^{-4}
	500	50	3.6×10^{-4}
	500	100	1.5×10^{-4}
	600	50	3.2×10^{-4}
	600	100	2.2×10^{-4}
Unbombarded	0	0	1.4×10^{-3}

Table 3. LIDTs of TiO₂ Films Deposited by IAD in the Case of Ion Current Density 50 $\mu\text{A}/\text{cm}^2$

Ion Energy/eV	300	400	500	600
Ar:O ₂ = 3:7		1.05	0.91	0.87
O ₂	1.24	1.08	1.09	1.08

Table 4. LIDTs of ZrO₂ Films Deposited by IAD

Ion Energy/eV	200	300	600	700
Ion current density/($\mu\text{A} \cdot \text{cm}^{-2}$)	20	50	100	100
LIDT	1	0.86	0.84	0.69

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Measurement of Solid Rapid Thermal Strain Induced by High-Intensity Laser

92P60372C Chengdu QIANG JIGUANG YU LIZI SHU [HIGH POWER LASER AND PARTICLE BEAMS] in Chinese Vol 4 No 2, May 92 pp 251-254

[Article by Qi Haibin [3344 3189 3453], Zhang Zhengwen [1728 2973 2429], and Qiu Zhanwu [6726 0594 2976] of the Applied Physics Department, National University of Defense Technology, Changsha 410073: "Measurement of Solid-Material Rapid Thermal Strain Induced by High-Intensity Laser"; MS received 11 Jan 91, revised 12 Jul 91]

[Abstract] The principle for measuring solid-material rapid thermal strain induced by high-intensity laser light, via temperature-compensation resistance strain gauges is presented, and measurements of an Al alloy exposed to a high-intensity CW CO₂ laser beam are introduced. The metal-plate thickness is 1 mm and laser light-spot diameter is 10 mm. The results indicate that this technique is suitable for measuring solid rapid thermal strain induced by a 3-second-duration high-intensity laser beam. Figure 1 [figure not reproduced] shows the measured curves of laser power, thermal strain output, and temperature rise vs. irradiation time, while Figure 2 [figure not reproduced] shows a graph of thermal strain of the laser-irradiated Al alloy vs. temperature rise. There are no tables.

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Experimental Studies of Saturated Soft X-ray Laser by Multi-target Coupling

40100067A Chengdu QIANG JIGUANG YU LIZI SHU [HIGH POWER LASER AND PARTICLE BEAMS] in Chinese Vol 4 No 2, May 92 pp 165-174

[Article by Wang Shiji, Gu Yuan, et al., of the Shanghai Institute of Laser Plasma, P.O. Box 8211, Shanghai 201800 and Chen Wannian, Lin Zunqi, and Fan Dianyuan of the Shanghai Institute of Optics and Fine Mechanics, CAS, P.O. Box 800-211, Shanghai 201800; MS received 28 Jan 92]

[Abstract] By use of "series multi-target coupling," Ne-like Ge soft x-ray laser output at wavelengths of 23.2 and 23.6 nm was observed on a line-focused two-beam Nd-glass laser with a wavelength of 1.05 μm . The pulse width was about 1 ns, with an irradiance of 0.8×10^{13} - 1.0×10^{13} W/cm² on the target surface. For the total target length of 5.6 cm, GL [gain-length] values reached 16 or so, and the divergence angles in the directions of both the target normal and target plane were all 3-4 mrad.

Reflectivity Measurements for 1.06 μm Laser Pulses Interacting with LY12 Aluminum Targets

40100067B Chengdu QIANG JIGUANG YU LIZI SHU
[HIGH POWER LASER AND PARTICLE BEAMS]
in Chinese Vol 4 No 2, May 92 pp 239-244

[Article by Liu Xufa, Li Qiming, and Liu Changling of the Southwest Institute of Fluid Physics, P.O. Box 523, Chengdu 610003; MS received 7 Jun 90, revised 13 Oct 91]

[Abstract] Reflectivities and spatial distributions of reflected light were measured with a multi-channel apparatus for 1.06 μm laser pulses interacting with LY12 aluminum targets in 1 atm air. As the laser power density changed from 1.68×10^4 to 6.08×10^4 W/cm² with target surface roughness 1.6 - 3.2 μm , the reflectivity reduced from 0.90 to 0.8 for long pulses. For 2.83×10^8 W/cm² short pulses, its reflectivity was 0.78. The experiments indicate that reflectivity and the spatial distribution of the reflected light are dependent on the temperature field of the targets, optical property of ablated surface and the mechanism of laser energy absorption by vapor plume.

High-power Microwave Radiation From Beam-plasma Interaction

40100067C Chengdu QIANG JIGUANG YU LIZI SHU
[HIGH POWER LASER AND PARTICLE BEAMS]
in Chinese Vol 4 No 2, May 92 pp 260-268

[Article by Liu Pukun and Yang Zhonghai of the University of Electronic Science & Technology of China, Chengdu 610054; MS received 18 Jun 91, revised 7 Oct 91]

[Abstract] Relativistic electron beam-plasma devices have the potential as one of the newest high-power microwave sources. In this paper, the process of microwave radiation at ω_p from beam-plasma interaction is investigated for $n_b/n_p \approx 0.01$, where n_b is the beam electron density and n_p the plasma density. The main instabilities have been analysed using the linear and nonlinear (Zakharov) dispersion relations. The dispersion relation of parametric decay by which unstable electrostatic waves are converted into electromagnetic waves has been derived. From this, the radiation rate of a beam-plasma system has also been

obtained. Finally, the energy flows from beam kinetic energy to plasma waves, then to EM radiation and plasma heating are modeled.

Simulations on Conjugation Field Using Deformable Mirrors

40100067D Chengdu QIANG JIGUANG YU LIZI SHU
[HIGH POWER LASER AND PARTICLE BEAMS]
in Chinese Vol 4 No 2, May 92 pp 284-290

[Article by Fu Changming, Lu Lixin, and Sun Jingwen of the Institute of Computer Application, CAEP [China Academy of Engineering Physics], P.O. Box 532, Chengdu 610003; MS received 6 Aug 91]

[Abstract] An algorithm for producing conjugation field using two deformable mirrors is presented. The algorithm is demonstrated effective by simulations using a Gaussian beam as the source. The simulations show that the smooth surface of deformable mirrors eliminates the local phase fluctuations on the first mirror, evidently improving the intensity pattern on the second mirror, and that for a Gaussian beam, the needed phase plane is very easily constructed with deformable mirrors. The effect of the distance between the mirrors is also discussed. Finally, ways to improve the present algorithm are discussed.

Low Neutron Yield Measurements in Laser-driven Implosions

40100067E Chengdu QIANG JIGUANG YU LIZI SHU
[HIGH POWER LASER AND PARTICLE BEAMS]
in Chinese Vol 4 No 2, May 92 pp 291-298

[Article by Chen Xiaofeng, Chen Yuting, et al., of the Southwest Institute of Nuclear Physics and Chemistry, P.O. Box 525, Chengdu 610003; MS received 30 Aug 91, revised 27 Dec 91]

[Abstract] A method to measure neutron yields produced in laser-driven DT-filled targets using recently developed arrays of BF₃ counters is introduced. The design and characteristics of the arrays, manufacture and effect of the time gate in the high-voltage circuit, and results of measurements at the "Shengguang" facility in 1990 are described.

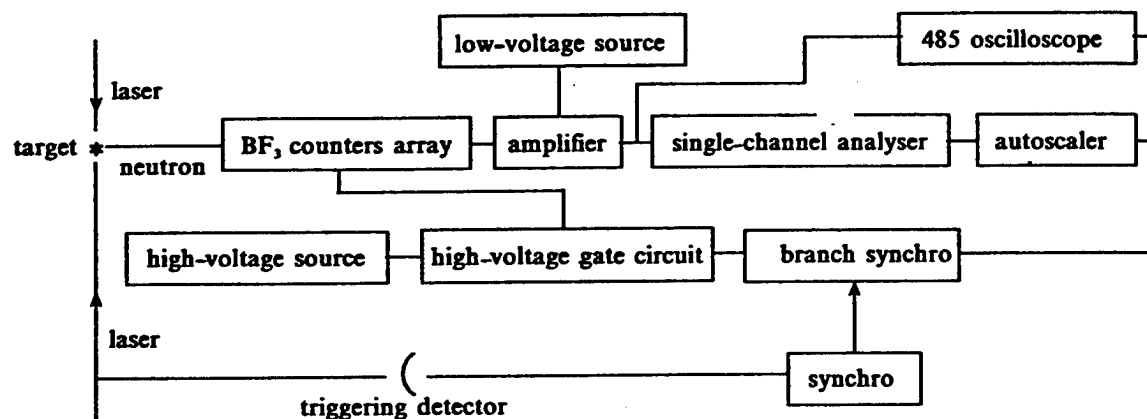


Figure 1. Schematic Diagram of Neutron Measurement Using BF₃ Counter Arrays

Table 1. Elementary Characteristics of the BF_3 Counter Arrays

No.	Elementary Structure	Sensitive Area, A_s/mm^2	Operation Voltage, U_0/V
A	Three ZJ-1306 BF_3 counters are parallelly inserted in cylindrical steel barrel (ϕ 180 mm) filled with paraffin and put on nine polythene rings as moderator	$\pi 140^2$	-2400
B	Four ZJ-1306 BF_3 counters are parallelly inserted in rectangular steel barrel (500 mm x 560 mm x 200 mm) filled with paraffin	500 x 460	-2600
C	Twenty-three BF_3 counters with glass shell are inserted in steel barrel filled with paraffin	600 x 340	-2600

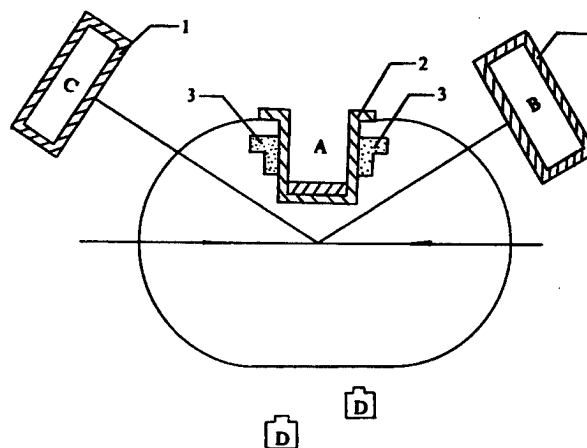


Figure 2. Schematic Diagram of the Experimental Setup. A, B, C, respectively represent BF_3 counter arrays. D represents plastic scintillator.

Key: 1. Pb 2. Barrel 3. Polythene rings

Table 2. Laser Parameters and Neutron Yields of Implosion

No.	Laser Parameters			Y_n Neutrons Per Shot				
	E_s/J , E_n/J	τ_s/ps , τ_n/ps	Direction	A	B	C	Average	Calculation As Equivalent Detective System
90110802NB	434, 405	850, 970	Perpendicular	5.71×10^{-3}	0	0	1.90×10^3	2.26×10^3 plus or minus 103%
90110901NB	480, 451	1040, 900	Perpendicular	5.71×10^{-3}	0	0	1.91×10^3	2.26×10^3 plus or minus 103%
90111901NB	715, 636	840, 860	Perpendicular	6.01×10^4	7.00×10^4	4.33×10^4	5.78×10^4	5.96×10^4 plus or minus 31%, $\Delta 2.8 \times 10^4$
90111902NB	706, 637	780, 840	Perpendicular	1.85×10^4	3.67×10^4	0.83×10^4	2.11×10^4	2.27×10^4 plus or minus 40%, $\Delta 7.0 \times 10^3$
90111903NB	743, 696	770, 750	Southeast, 25°	5.87×10^{-3}	6.59×10^{-3}	0	4.15×10^3	4.71×10^3 plus or minus 74%
90112001NB	711, 418	800, 790	Southeast, 25%	5.71×10^{-3}	0	0	1.90×10^3	2.26×10^3 plus or minus 101%
90112002NB	639, 773	810, 770	Southeast, 25%	3.46×10^5	3.30×10^5	2.41×10^5	3.05×10^5	3.15×10^5 plus or minus 25%, $\Delta 1.5 \times 10^5$

Table 2. Laser Parameters and Neutron Yields of Implosion

No.	Laser Parameters			Y_n Neutrons Per Shot				
	$E_s/J, E_n/J$	$\tau_s/ps, \tau_n/ps$	Direction	A	B	C	Average	Calculation As Equivalent Detection System
90112101NB	517, 709	1, 1110	Southeast, 25%	1.14×10^4	1.21×10^4	7.80×10^3	1.04×10^4	1.08×10^4 plus or minus 51%
90112202NB	600, 656	620, 690	Perpendicular	1.14×10^4	0	0	3.80×10^3	4.53×10^3 plus or minus 74%
90112302NB	666, 663	670, 810	Southeast, 30%	0	0	7.73×10^3	2.57×10^3	1.86×10^3 plus or minus 103%
90112603NB	680, 578	890, 700	Perpendicular	5.71×10^3	0	0	1.90×10^3	2.26×10^3 plus or minus 103%

Note: A presents neutron yields obtained with scintillation detectors, in No. 90111901, 90111902 and 90112002.

Effects of Random Errors of Wiggler Magnetic Fields on FEL Gain and Output

40100067F Chengdu QIANG JIGUANG YU LIZI SHU
[HIGH POWER LASER AND PARTICLE BEAMS]
in Chinese Vol 4 No 2, May 92 pp 299-304

[Article by Dong Zhiwei, Tian Shihong, and Yang Zhenhua of the Institute of Applied Physics and Computational Mathematics, P.O. Box 8009, Beijing 100088; MS received 3 Jul 91, revised 3 Jan 92]

[Abstract] Based on Prof. Yu Min's FEL longitudinal mode theory, the small-signal and exponential growth rates including the effect of wiggler magnetic-field random errors have been obtained, and with SG-1 parameters, the scaling relation between exponential growth rate parameter g_0 and magnetic-field random error σ is provided. The results of linear theory have been verified by 3-D simulations.

The Radiation Field Eigenmodes in Gain Media—The 3-D Solutions of Free Electron Lasers and Optical Guiding

40100067G Chengdu QIANG JIGUANG YU LIZI SHU
[HIGH POWER LASER AND PARTICLE BEAMS]
in Chinese Vol 4 No 2, May 92 pp 305-313

[Article by Shi Yijin of the Institute of Atomic Energy of China, P.O. Box 275, Beijing 102413; MS received 25 Sep 91, revised 28 Dec 91]

[Abstract] A set of eigenmodes of radiation field is obtained in the media with quadratic equivalent index of refraction. Taking the set of eigenmodes as expansion basis, the fully 3-D problems relative to free electron lasers can be solved in the frame of perturbation approach. The optical guiding of

FELs by the off-axis displacement of the electron beam is treated as an example of 3D-FEL problems.

MOVPE Growth, TEM Characterization of GaAs/Al_xGa_{1-x}As Superlattices

92P60402B Shanghai HONGWAI YU HAOMIBO
XUEBAO [JOURNAL OF INFRARED AND
MILLIMETER WAVES] in Chinese
Vol 11 No 2, Apr 92 pp 139-144

[Article by Xu Xiangang [1776 3807 0474], Huang Baibiao [7806 2672 2871], et al. of the Institute of Crystal Materials, Shandong University, Jinan, Shandong 250100, China: "MOVPE Growth, TEM Characterizations of GaAs/Al_xGa_{1-x}As Superlattices"; Ms received 14 Oct 91, revised 23 Feb 92. Project supported by grant from NSFC; paper delivered at International Workshop on Spectroscopy and Optoelectronics of Condensed Matters, 14-17 October 1991, Shanghai, China]

[Abstract] MOVPE [metallo-organic vapor phase epitaxy] growth of GaAs/Al_xGa_{1-x}As superlattices (SLs) and their applications in optoelectronic devices such as self-electrooptic-effect devices (SEEDs) and high electron mobility transistors (HEMTs) are reported. A typical HEMT consists of a semi-insulating GaAs substrate, covered by a 300-A-thick GaAs transition layer, followed by a 10-period GaAs (100A)/Al_{0.5}Ga_{0.5}As (200A) SL buffer layer, with the usual HEMT structure at the top of the device. A typical SEED consists of a semi-insulating GaAs substrate, covered by a 10 1/2-period Al_{0.1}Ga_{0.9}As/Al_{0.8}Ga_{0.2}As high-reflectivity layer, an N-type Al_{0.4}Ga_{0.6}As layer, a 5-period Al_{0.1}Ga_{0.9}As (50A)/Al_{0.3}Ga_{0.7}As (50A) SL buffer layer, a 50-period GaAs (100A)/Al_{0.3}Ga_{0.7}As (100A) SL optical interaction region, and finally a 2000-A-thick P-type GaAs contact layer. Epilayer quantum heterostructures are characterized with

cross-sectional transmission electron microscopy (TEM). In SEEDs, the SL interfaces are abrupt and barrier and well layers have good uniformity. In some HEMTs, SLs used as buffer layers smooth out the surface growth roughness. Six figures show various TEM images and schematic diagrams of the HEMT and SEED structures. References: 5 English, 4 Chinese.

Visible Light Emission from Highly Porous Silicon

92P60402C Shanghai HONGWAI YU HAOMIBO XUEBAO [JOURNAL OF INFRARED AND MILLIMETER WAVES] in Chinese
Vol 11 No 2, Apr 92 pp 159-161

[Article by Zong Xiangfu [1350 4382 4395], Weng Yumin [5040 3254 3046], et al. of the Institute of Materials Science, Fudan University, Shanghai 200433, China: "Visible Light Emission from Highly Porous Silicon"; MS received 15 Apr 92. Paper delivered at International Workshop on Spectroscopy and Optoelectronics of Condensed Matters, 14-17 October 1991, Shanghai, China]

[Abstract] The quantum wire array fabricated from porous silicon is an important new high-tech material with applications in optoelectronics. The authors report the use of hydrofluoric acid electrolytic etching to develop porous-Si quantum wire array material exhibiting photoluminescence (PL) with a peak wavelength as short as 570 nm (blue-green). Initial estimation places the diameter of the microholes in the material at under 18 angstroms. The material has been used to develop a current-injection Schottky diode exhibiting yellow electroluminescence (EL). Four figures show a photograph of a wafer, the PL spectra of different areas of the wafer, room-temperature EL spectra of a porous-Si-based Schottky diode, and an EL photo of the diode, respectively. References: 1 Chinese, 2 English.

Quasi-CW Frequency-Doubled YAG-Laser-Pumped Ti:Sapphire Laser Certified

92P60393G Beijing ZHONGGUO KEXUE BAO [CHINESE SCIENCE NEWS] in Chinese 24 Jul 92 p 1

[Untitled photoreport by XINHUA staff reporter]

[Summary] The "quasi-CW frequency-doubled YAG-laser-pumped Ti:sapphire laser" developed by a Tianjin University Laser Teaching and Research Section team led by Prof. Yao Jianquan [1202 1696 6898] passed expert appraisal on 4 July. This 2.7-watt-output-power laser has applications in space remote sensing technology, optoelectronic countermeasures, laser medicine, and laser fusion, among other areas. [Photograph not reproduced]

Frequency Tripling of 1341.4 nm Nd:YAP Laser for Obtaining 447.1 nm Blue Coherent Radiation

40100069B Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese
Vol 19 No 5, May 92 pp 381-383

[English abstract of article by Lin Wenxiong, Zeng Zhengdong, and Shen Hongyuan of Fujian Institute of Research on the Structure of Matter, CAS, Fuzhou; MS received 26 Dec 90, revised 11 Feb 91]

[Text] The 670.7 nm coherent radiation was obtained by SHG of 1341.4 nm Nd:YAP laser in LiIO₃ crystal and 447.1 nm blue coherent radiation was obtained by frequency summing in the KTP crystal. The values of phase matching angle and effective nonlinear coefficient were calculated for the mentioned nonlinear optical processes. The experimental results are in good agreement with calculation.

Excimer Laser-Induced Deposition of Manganese and Tungsten Thin Films

40100069A Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese
Vol 19 No 5, May 92 pp 357-362

[English abstract of article by Xu Jie, Lu Xinming, and Lou Qihong of Shanghai Institute of Optics and Fine Mechanics, CAS, Shanghai; MS received 9 Oct 90]

[Text] The deposition of manganese and tungsten thin films by 308 nm XeCl excimer-laser-induced photolysis of manganese pentacarbonyl dimer Mn₂(CO)₁₀ and tungsten hexacarbonyls W(CO)₆, respectively, is reported. The dependence of the features of the thin films on the experimental parameters has been studied.

Low-Threshold-Current 1.5-μm PBR-DFB Laser Diode Developed, Used in Domestic 140 Mbps Coherent Optical Communications System

92FE0604A Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese
Vol 13 No 5, May 92 pp 279-286

[Article by Wang Wei [3769 0962], Zhang Jingyuan [1728 7234 1254], Wang Xiaojie [3076 1321 2638], Tian Huiliang [3944 1979 5328], Miao Yubo [4924 5148 0590], Zhang Jizhi [1728 3444 1807], and Wang Baojun [3769 1405 6511] of the National Key Joint Laboratory for Integrated Optoelectronics, Institute of Semiconductors, Chinese Academy of Sciences: "Low-Threshold 1.5 μm PBR-DFB Laser"; MS received 7 Mar 91, revised 7 May 91]

[Text] Abstract

A highly stable single-longitudinal-mode-output (SLM) 1.5 μm DFB (distributed feedback) laser with a less than 15 mA threshold current at ambient temperature was developed using the proton-bombarded PBR [planar buried ridge] structure. It serves as a solid foundation for the development of long-life uncooled 1.5 μm DFB laser systems in the future. The stable SLM operation covers a wide temperature range (-40 to +60°C) over a large current range (1.2 to 3 I_{th} [threshold current]). The side-mode suppression ratio (SMSR) is as high as 30 dB. The static linewidth is typically 30-40 MHz and can be as narrow as 20 MHz. Based on an accelerated aging test at 50°C, it is extrapolated that the device can operate continuously for 3,000 hours at 20°C without substantial signs of deterioration. This device has been used as a signal source on a 140 Mbps coherent optical communications system in China.

1. Introduction

Very rapid progress has been made in the development of 1.5 μm grating feedback DFB/DBR [distributed Bragg reflector] laser diodes as signal sources in high-speed,

large-capacity, long-range fiber-optic communications. In order to improve the yield of the SLM device, various phase-shift compensation structures have been used^{1,2,3} and yield has been raised to above 95 percent.⁴ This creates the condition for the commercialization of DFB/DBR laser diodes. As a signal source for high-speed modulation, the Thomson-CSF center in France introduced a proton-bombarded PBR-DFB structure.⁵ Proton bombardment is used to create high resistance along the two buried strips to minimize the distributive capacitance of the device. Consequently, the modulation speed of the device is increased. In order to make it more practical, the authors developed a simple RW (ridge-waveguide) DFB laser diode.⁶ Although this device could maintain a high SMSR (> 30 dB) over a wide temperature (2°C-45°C) and current (1.2-2.2 I_{th}) range, the width of the active region could not be made narrower than 4 μm due to the technique used. Hence, the room temperature threshold is usually around 40 mA. Because of the high operating current, the device tends to be unstable which would cause many problems in a real communications system.

This paper presents a 1.5 μm low-threshold PBR-DFB laser diode with a typical room-temperature threshold of around 12 mA. This makes it possible to build a device without a cooler and creates the necessary condition for the fabrication of practical devices and for the simplification of long-range relay-free communications systems.

II. Design of DFB Laser Diode and Key Technique

1. Determination of Grating Position and Period

In a DFB laser, the grating may be engraved on the InP substrate. Then, a GaInAsP active layer and a waveguide layer are grown on top of the grating. Or, the active layer and waveguide layer may be grown first and the grating is engraved on the waveguide. The latter approach was chosen. The advantages are as follows: (1) An InP transition layer can be grown on top of the InP substrate before putting on the active layer. Thus, we can avoid any structural defects introduced by growing the active and waveguide layers directly on top of the uneven grating. (2) The thicknesses and gain peaks of the epitaxial active layer and waveguide layer may be measured. This helps the design of the grating period.

As for the DFB grating structure chosen, it is a planar waveguide with five steps in the index of refraction, as shown in Figure 1; n_1 and n_5 are the refractivity of the n^+ layer and the refractivity of the P^+ -InP layer, respectively, n_2 and n_3 are the refractivity of the active layer and that of the waveguide, respectively, and n_4 represents the average refractivity of the grating layer (i.e., periodically alternating structure of GaInAsP and InP). The thicknesses of the active, waveguide and grating layer are a , w and g , respectively. An analytical expression of the effective index of refraction, n_e , can be derived as follows:⁷

$$(s/r + z/s \cdot \tan \beta) \cdot \sin h(s \cdot g) -$$

$$(z/r - \tan \beta) \cdot \cos h(s \cdot g) = 0,$$

where s , r , t and β are functions of the indices of refraction and thicknesses of different layers and the effective index

of refraction n_e . The effective index of refraction of the active waveguide layer, n_e , can be determined by numerically plugging the values of n_1 , n_2 , n_3 , n_4 , n_5 , a , w and g into the equation. For example, when $n_1 = n_5 = 3.162$, $n_2 = 3.534$, $n_3 = 3.407$, $n_4 = 3.246$, $a = 0.12 \mu\text{m}$, $w = 0.13 \mu\text{m}$ and $g = 0.06 \mu\text{m}$, then $n_e = 3.271$. Based on the calculated value of n_e , from Bragg's law of diffraction, i.e., $\Lambda = m \times (\lambda_B / 2n_e)$, the period of a second-order grating ($m = 2$) corresponding to a Bragg wavelength of 1.540 μm is $\Lambda: n_e = 15,400 / 3.271 = 4,720$ Angstroms.

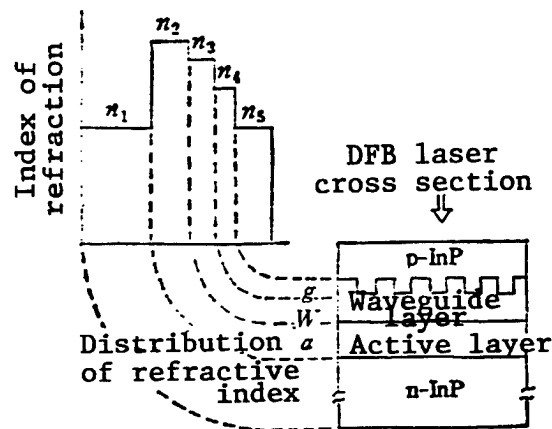


Figure 1. Distribution of Refractivity in the Five-Layer Waveguide Structure

2. Plasma Removal of Photoresist and Reactive Ion Etching (RIE) in Grating Preparation

The most difficult problem is to reproducibly fabricate large-area uniform gratings. The holographically exposed pattern is treated with plasma to remove the photoresist and this is followed by RIE to carve out the waveguide. Figure 2 [photograph not reproduced] shows a cross section of an etched grating. The depth of the grating is over 1,000 Angstroms.

3. Selection of Solution Saturation for Secondary Epitaxy

Usually, the grating depth on the GaInAsP is only approximately 0.08 μm . In LPE (liquid phase epitaxy), if the over-saturation of the solution during the growth of the InP restriction layer is not carefully controlled, the GaInAsP grating will be re-dissolved during the formation of the GaInAsP-InP interface transition layer. The key to overcoming this problem is to choose a super-cold solution to rapidly form a (GaInAsP)⁺-(In + P)¹ solid-liquid interface to stop the GaInAsP grating from re-dissolution. In addition, the super-cold solution also provides the driving force for nucleation to start the growth of the InP restriction layer. The atomic fraction of phosphorus saturation in In-rich solutions at different temperatures can be expressed by an empirical equation introduced by J. J. Hsieh:⁸

$$X'_P = 1.76 \times 10^3 \exp(-11411/T).$$

We then can calculate the amount of InP required, i.e., w_{InP} , to saturate a gram of In solution at any given temperature:

$$w_{\text{InP}} = X'_p \cdot M_{\text{InP}} / (1 - 2X'_p) \cdot A_{\text{In}},$$

where M_{InP} is the molecular weight of InP and A_{In} is the atomic weight of In. Based on our experimental result, the over-saturation of the 595°C epitaxial solution is 15°C, i.e., 5.1 mg of InP is added to every gram of In.

4. Strip Structure and Tertiary Epitaxy

The PBR structure selected is shown in Figure 3. The strip was prepared by using an etchant to etch it up to the waveguide layer. The advantage is that this is done before the buried region is grown so that the sides of the active region are not exposed; this avoids contamination and thermal damage prior to epitaxy and lengthens the useful life of the device. In addition, etching also re-exposes the sides of the grating after two epitaxial steps. This provides a direct measure of the quality of the secondary epitaxial InP restriction layer on the grating.

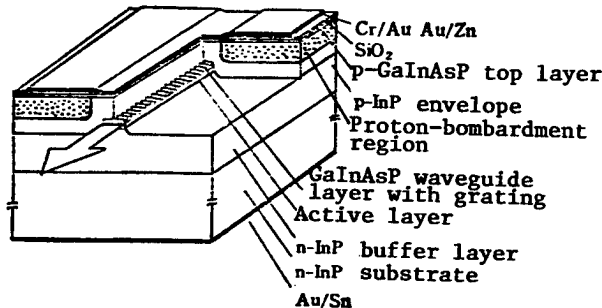


Figure 3. Structure of the PBR-DFB Laser

Before the third epitaxial step (to grow the buried region), a suitable unsaturated InP solution is used to re-dissolve a portion of the strip and the grating on the sides. In order to minimize the distributive capacitance of the device and to prevent leakage due to conduction of the homogenous p-n junction in the buried region under a large driving current, a semi-insulating high-resistance zone is formed by proton bombardment in the buried region. It was experimentally found that the depth of proton bombardment is proportional to the energy of bombardment. At a bombardment dose of $5 \times 10^{13} \text{ cm}^{-2}$, the depth-to-energy ratio is $0.8 \mu\text{m}/10 \text{ keV}$.

III. Characteristics and Analysis of DFB Laser Diode

1. Room-Temperature Threshold Current and Linear Output Power

Since the blocking region in the PBR structure is a forward InP junction, when the driving current rises, the voltage drop of the device also increases. Hence, the leakage current in the blocking region also goes up. Figure 4(a) shows the light intensity vs. current and voltage vs. current curves for a conventional PBR-DFB laser diode. When the voltage exceeds a certain value, the V-I [voltage vs. current] line begins to curve. The differential series resistance falls and the

current increases rapidly with voltage. This indicates that the forward InP junction is conducting. Correspondingly, the intensity vs. current line also curves and the light emitting efficiency falls. In order to overcome this leakage problem in the blocking region of the PBR structure, a high-resistance region is formed by proton bombardment. Figure 4(b) shows the L-I [intensity vs. current] and V-I characteristic curves of

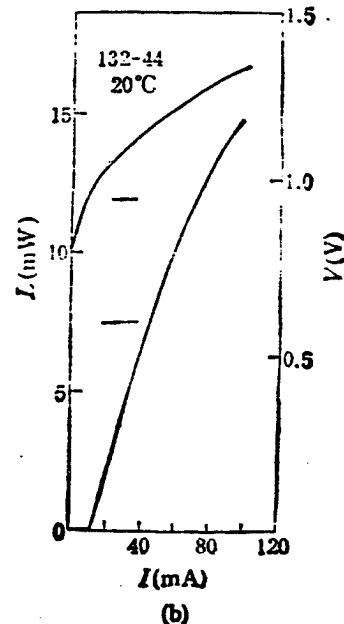
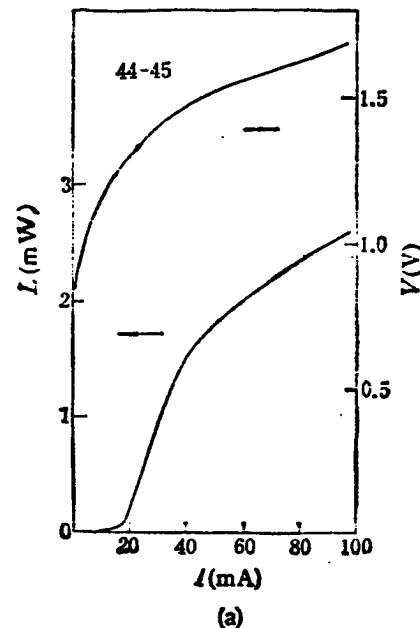


Figure 4. (a) Laser Intensity vs. Current and Voltage vs. Current Curves for a Leaky PBR-DFB Laser Diode, (b) Laser Intensity vs. Current and Voltage vs. Current Curves for a Proton-Bombarded PBR-DFB Laser Diode

a proton-bombarded PBR-DFB laser diode. There are no deflection points and the linearity of the L-I curve has been substantially improved. The maximum linear light output is 10 mW and the single-face external differential quantum efficiency is 22 percent. The maximum lasing temperature of a typical device has exceeded 85°C.

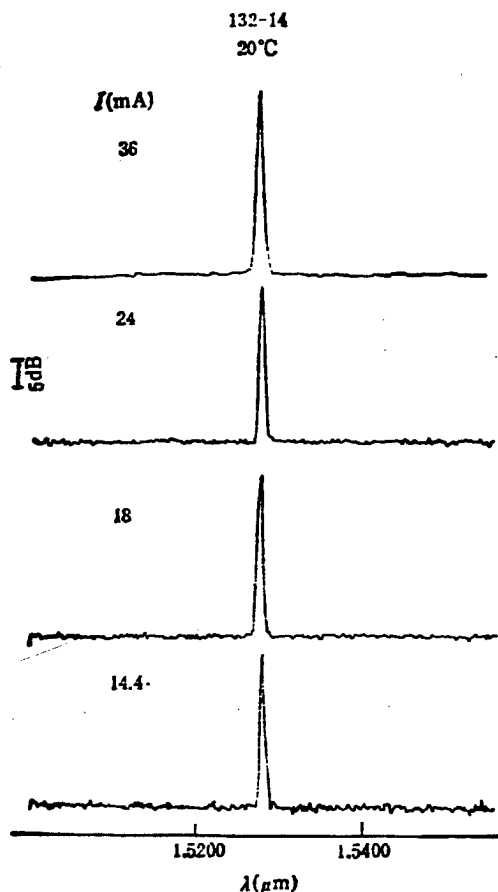


Figure 5. PBR-DFB Laser Spectra at 20°C Driven by 1.2-3 I_{th}

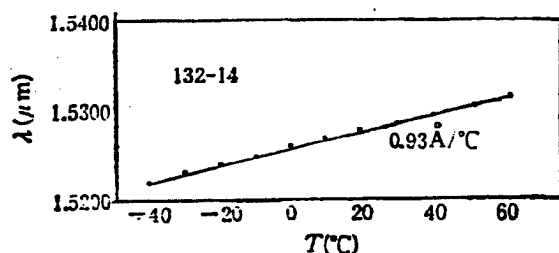


Figure 6. Typical Wavelength vs. Temperature Plot for a PBR-DFB Laser Diode

2. Steady-State Spectra

In spectral measurement, PbS is used as the detector. The amplifier is a U.S.-made EG 5208 lock-in amplifier; its logarithmic scale was used. The monochromator is a WDG30 monochromator manufactured by the Beijing Optical Instrument Plant. The laser could either be driven by a constant current source or a high-frequency signal source (f : 0.1-2.1 GHz, amplitude 16 dBm). The system is equipped with a temperature control unit (U.S. firm FTS Systems, Inc.) which operates over a temperature range of -70 to 150°C. Spectral measurement can be performed at various current levels and temperatures.

Figure 5 shows the typical spectra of the device at 20°C over a current range of 1.2 to 3 times the threshold current. The main-to-side-mode intensity ratio is as high as 33 dB. We also measured the spectra at 1.5 times threshold current at different temperatures. Over the 100°C of measurement, they are all in stable SLM operation with a main-to-side-mode ratio of more than 30 dB. Based on the wavelengths measured for the same longitudinal mode at different temperatures, a wavelength vs. temperature plot shows a linear relation and the slope of the straight line is 0.93 Å/°C, which is the wavelength temperature coefficient (see Figure 6).

It is well known that the major difference between a single-mode DFB laser and a F-P cavity face laser is that the former can operate steadily in SLM over a wide temperature range (-40 to 60°C) at different current levels ($1.2 I_{th}$ - $3 I_{th}$). Experimentally, it was discovered that their spontaneous emission spectra near the threshold are also quite different. Figure 7 shows the emission spectra of the DFB laser at different current levels. The lowest curve is the spontaneous emission spectrum at $0.9 I_{th}$, which already exhibits an apparent mode. This shows that a particular mode has a high net gain, i.e., the device has a very strong mode selectivity. Once the current exceeds the threshold value (see the three spectra above), this mode is selected. Therefore, the spontaneous emission spectrum can be used as the basis for preliminary selection of SLM laser diodes.

3. Steady-State Linewidth

The steady-state linewidth of a typical device was measured using the zero-beat delay method developed by the Department of Electronic Engineering of Qinghua University; results are shown in Table 1.

Table 1. Steady-State Linewidth of a Typical 1.5 μ m PBR-DFB Laser Diode

Device sample number	Temperature (°C)	Threshold I_{th} (mA)	Operating current (mA)	Steady-State linewidth (MHz)
56	16.5	10	20	60
			30	24
105	16.5	10	20	40
			30	28
			40	20

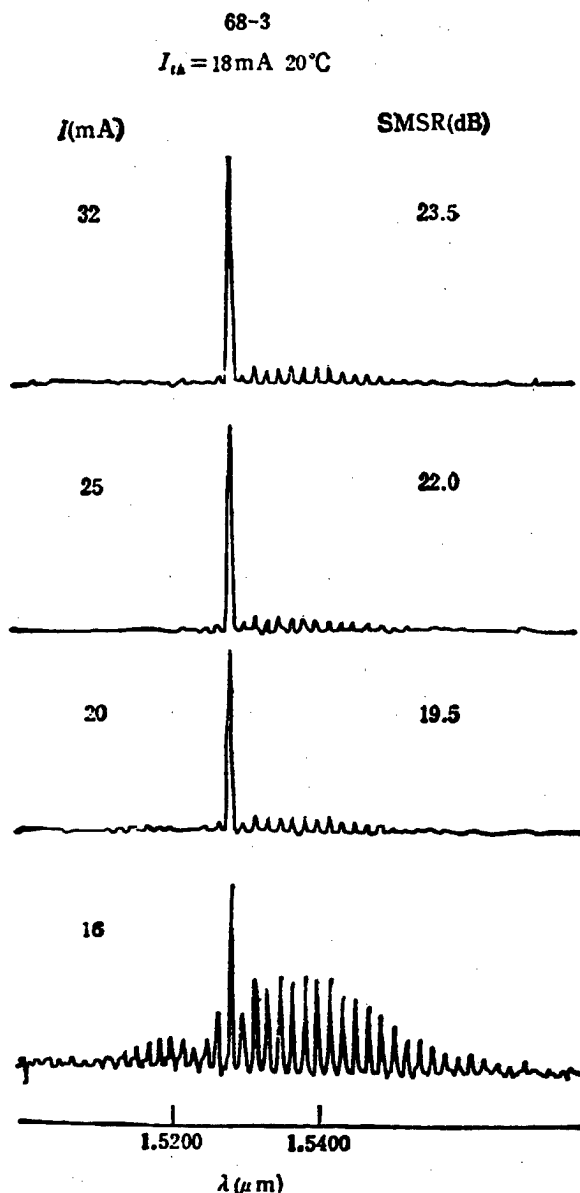


Figure 7. Emission Spectra of SLM PBR-DFB Laser Diode Driven at Different Current Levels

From Table 1, one finds that the linewidth narrows with increasing power output (operating current). Figure 8 [photograph not reproduced] shows the beat frequency spectra of a typical device. At 30 mA, the linewidth is 24 MHz.

4. Dynamic Behavior

Dynamic spectra of the device were measured with 1 GHz sinusoidal modulation (bias current $I_b = 2 I_{th}$). Figure 9 shows the dynamic spectra of a typical PBR-DFB laser at different degree of modulation m at 1 GHz. With increasing degree of modulation, the linewidth broadens.

This means that although the laser diode can still operate in SLM ($\text{SMSR} > 25 \text{ dB}$), under high-frequency modulation due to the tremendous loss difference between the main and side mode provided by the grating, the injected carrier density must fluctuate at a larger amplitude as the degree of modulation increases. This causes the amplitude of variation of the effective index of refraction of the active region to expand. Consequently, the range of period shift of the emission wavelength is also increased. Based on the figure, the dynamic linewidth is about 3 Angstroms at 100 percent modulation with a SMSR of about 25 dB. The device has been successfully used as a signal source for a 140 Mbps [i.e., DS4] coherent optical communications system.

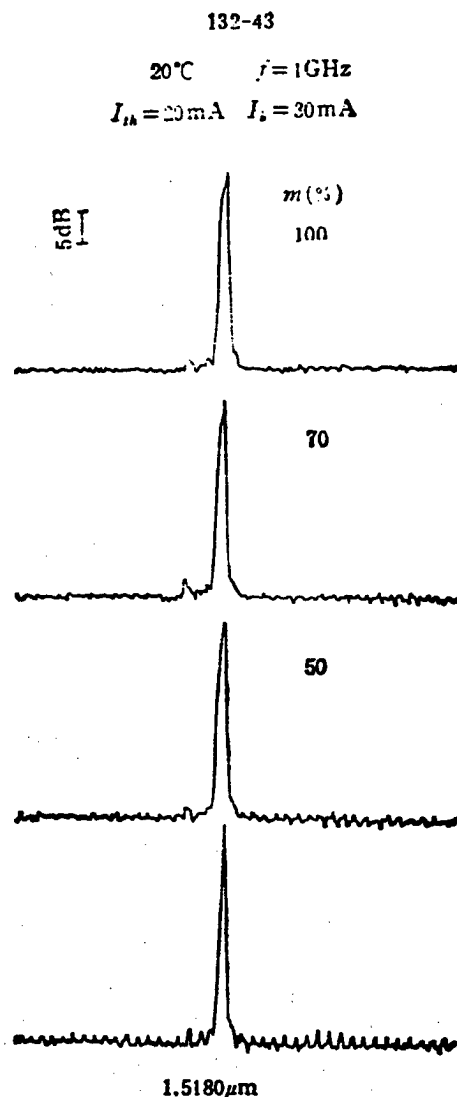


Figure 9. Dynamic Spectra of a Typical PBR-DFB Laser Diode at Different m at 1 GHz

5. CW Life at Room Temperature

Five devices were selected at random during the evaluation period for a constant-power, high-temperature accelerated aging test (50°C, 1 mW constant power). After 250 hours of continuous operation, their thresholds were measured at 20°C without showing any significant changes. Assuming that the activation energy of slow deterioration is 0.7 eV, the extrapolated room-temperature CW life is $\tau(20) = 13.14 \times \tau(50) = 13.14 \times 250 = 3,285$ hours.

IV. Conclusions

A proton-bombarded PBR structure is employed to lower the threshold of the 1.5 μm DFB laser diode. The leakage current in the buried region is suppressed to improve the linearity of the light output. Typical room-temperature threshold current is 12 mA with a minimum of 9 mA. This provides a solid foundation for the fabrication of uncooled 1.5 μm DFB laser devices. The linear output power is usually 10 mW and the single-face external differential quantum efficiency is 22 percent. The maximum lasing temperature is 85°C. From 1.2 to 3 times the threshold, SMSR is as high as 33 dB. The steady-state linewidth is usually 40-50 MHz and can be as narrow as 20 MHz. The temperature range of steady SLM operation is over 100°C.

Preliminary aging experiments were performed on the devices. The extrapolated CW life at room temperature is estimated to be over 3,000 hours. From the standpoint of practicality (at least 10,000 hours), more work is still required to meet the needs for optical communications. Presently, we are working to eliminate the stress and interface defects induced by the grating. Furthermore, techniques involving electrodes—such as sintering and welding—are being improved to lengthen the useful life of the device.

In order to improve the yield of the DFB laser diode, in addition to studying phase-shift compensation or AR-HR coatings on the grating or strip, our experiment shows that the uniformity of the epitaxial component is also critical. We need to use MOCVD, instead of LPE, to obtain epitaxial film of even thickness and uniform composition.

Acknowledgments

The authors wish to thank Ma Chaochua [7456 2600 5478], Wang Liming [3769 7787 2494], Lu Hui [0712 0583], Zhang Hongqin [1728 3163 3830], and Guan Wei [7070 4885] for the post-treatment of devices; Chen Jiying [7115 4764 5391] for performing the RIE; and Zhang Hanyi [1728 3352 0001], Xie Shizhong [6200 0013 6988], Sun Bo [1327 3134], and Yang Peisheng [2799 1014 3932] for their assistance and constructive suggestions in testing the characteristics of the device.

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Large Optoelectronic Theodolite Certified

92P60393E Beijing ZHONGGUO KEXUE BAO [CHINESE SCIENCE NEWS] in Chinese 17 Jul 92 p 1

[Article by Deng Xianchun [6772 6343 2504]: "Large Optoelectronic Theodolite Meets Advanced International Standards"]

[Summary] Chengdu (ZHONGGUO KEXUE BAO wire report)—The model 778-II large optoelectronic theodolite jointly developed by the CAS Institute of Optoelectronic Technology and MMEI's Institute 11 passed a CAS-organized technical appraisal in Chengdu on 2-3 July. The panel of over 70 experts appraised the new device's overall performance as matching the international state-of-the-art. This new theodolite, which has three automatic tracking and measurement modes—TV, infrared, and laser—is oriented to high-accuracy, long-range tracking of space vehicles. Other applications include astronomy, scientific research, and industrial measurement.

New-Generation Acoustic Measurement Instruments Developed

92P60366B Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 29 Jun 92 p 1

[Article by Dai Meihua [2071 5019 5478]: "New-Generation Acoustic Measurement Instruments Developed"]

[Summary] Engineers at the CAS Institute of Acoustics recently developed two new acoustic measurement instruments: the "DSG-1 all-digital acoustic chart recorder" and the "ASAW-1 acoustic signal analysis workstation." These international state-of-the-art instruments integrate micro-computer technology with digital signal processing (DSP) technology, and incorporate the high-speed DSP hardware and peripherals developed by the institute [see JPRS-CST-92-007, 16 Apr 92 pp 20-24]. The acoustic chart recorder has high-capacity data acquisition circuits, produces high-definition acoustic plots and has a variety of functions, including LPC [linear predictive coding] analysis and extraction of fundamental frequency and resonant peak. Applications include phonetics, linguistics, and biomedicine.

SM35A MOVPE Equipment Certified

92P60395A Beijing ZHONGGUO DIANZI BAO
[CHINA ELECTRONICS NEWS] in Chinese 6 Jul 92
p 3

[Unattributed photoreport]

[Summary] The model SM35A metallo-organic vapor phase epitaxy (MOVPE) equipment developed by the CAS Institute of Semiconductors for fabrication of superlattice and quantum-well structure materials has been formally certified. This equipment is ideal for fabricating GaInSb/GaSb superlattice materials, samples of which have proven to be at the worldwide state-of-the-art. [Photograph not reproduced]

GAL Deciphering Programmer Certified

92P60395B Beijing ZHONGGUO KEXUE BAO
[CHINESE SCIENCE NEWS] in Chinese 17 Jul 92 p 2

[Article by Zhang Jianping [1728 1696 1627]: "China University of Science and Technology Markets New Deciphering [Programmer] Device: Targets International Digital Circuit Technology"]

[Summary] Hefei (ZHONGGUO KEXUE BAO wire report)—The model GDP-3 generic array logic (GAL) deciphering programmer developed by scientists in the Modern Physics Department at China University of Science and Technology was recently formally certified. Incorporating "transient recovery of an enciphered bit" technology, this state-of-the-art device is a deciphering programmer designed to provide highly effective, accurate, non-destructive deciphering of any enciphered GAL chip. The programming software's main performance indicators surpass those of the comparable foreign-made product. Deciphering success rate and accuracy are 100 percent; deciphering speed is 3-5 seconds per chip, a rate 300-3,000 times faster than currently available deciphering programmers.

High- T_c Superconducting Thin-Film Three-Terminal Josephson Devices Fabricated

92P60403 Hefei DIWEN YU CHAODAO

[CRYOGENICS AND SUPERCONDUCTIVITY]

in Chinese Vol 20 No 2, May 92 pp 59-62

[Article by Wan Fabao [8001 4099 1405], Fan Jiangshui [2868 3068 3055], et al. of the Superconductor Physics Lab, Dept. of Physics, Northwestern University, Xian; Qi Zhenzhong [2058 7201 0022], Yao Weiguo [1202 0251 0948], and Shi Jianzhong [4258 1696 0022] of the CAS Institute of Solid State Physics, Hefei; and Wang Shulin [3769 2885 2651] of the Xian College of Mining and Metallurgy: "High- T_c Superconducting Thin-Film Three-Terminal Device"; MS received 2 Dec 91, revised 14 Feb 92]

[Abstract] High- T_c superconducting three-terminal Josephson devices with normal metal gates have been fabricated from YBCO superconducting thin films. The YBCO epitaxial thin film, prepared by magnetron sputtering, has a thickness of 4000 Å, a T_c of 90K, and J_c exceeding 1×10^5 A/cm² (at 77 K, zero magnetic field). An OMR [Omron Corp.] (Japan) negative photoresist was used for one-step wet photoetching of the YBCO thin-film microbridge. Then, an AZ1350 (Japan) positive photoresist was used for two-step photoetching, and the 2000-Å-thick metal (Ag, Cu, Al) thin films were deposited via vacuum evaporative plating. Finally, a strip-off technique was used to complete fabrication of the entire superconducting thin-film three-terminal device. The three microbridges have dimensions of $30 \mu\text{m} \times 5 \mu\text{m}$, $20 \mu\text{m} \times 5 \mu\text{m}$, and $10 \mu\text{m} \times 5 \mu\text{m}$, and the corresponding gate widths are 5, 10, and 15 μm . The change in the DC I-V [current vs voltage] characteristics is sharper than that of a microbridge. When quasi-particles were injected through the gate, the critical current fell, which may be due to nonequilibrium superconductivity from the excess injected quasi-particles. Figure 1 below is a schematic diagram of the device, while Figures 2-5 (not reproduced) show a micrograph of a high- T_c superconducting thin-film microbridge, a micrograph of the entire device, graphs of the DC I-V characteristics of high- T_c superconducting thin-film microbridges with and without metal gates, and a graph of the current modulation after gate injection of the quasi-particles, respectively.

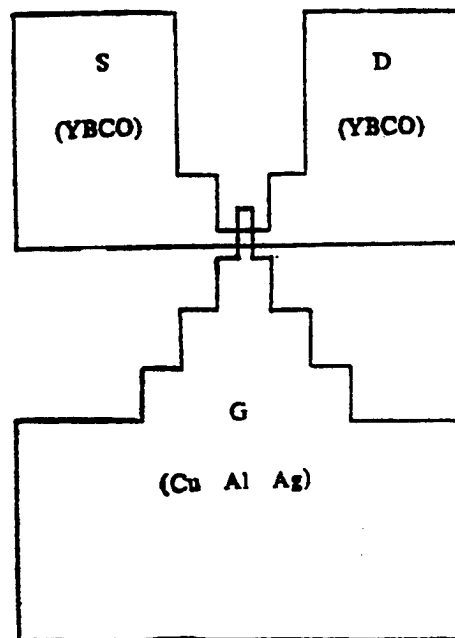


Figure 1. Schematic Diagram of High- T_c Superconducting Three-Terminal Device (S = source; D = drain; G = gate)

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Construction To Begin on Nation's Largest Satcom Network

92P60367A Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 23 Jun 92 p 1

[Article by Yan Yan [2518 3601]: "Construction To Begin on Nation's Largest Satellite Communications Network"]

[Text] On 21 June in Beijing, a contract was signed for construction of the nation's current largest satellite communications (satcom) network, the China Tongpei [4827 6792] Coal Mine Corp. satcom project (Phase II). In charge of the design and construction for this communications project is the Ministry of Aerospace Industry (MAI) satellite applications union, which in the next 18 months will complete design and installation of 62 communications stations. At completion time, the China Tongpei Coal Mine Corp. will have the nation's largest and best satcom network. It is understood that construction of 10 communications stations for the China Tongpei Coal Mine Corp.'s communications network (Phase I) project is now complete; Phase I design and construction were also undertaken by MAI's satellite applications union.

1.5 μ m Experimental Heterodyne FSK Coherent Optical Fiber Communication System With External Cavity Semiconductor Lasers

40100070A Beijing TONGXIN XUEBAO [JOURNAL OF CHINA INSTITUTE OF COMMUNICATIONS] in Chinese Vol 13 No 1, Jan 92 pp 52-57

[English abstract of article by Guan Kejian, Guo Jianen, Li Ling, Jiang Peixuan, and Ye Peida of the Optical Communication Lab., Beijing University of P&T; MS received 6 May 91]

[Text] A 1.5 μ m experimental heterodyne FSK coherent optical fiber communication system in which all components are designed and fabricated domestically is reported. In the experimental system, InGaAsP GRINROD and grating external cavity semiconductor lasers are used as transmitter and local oscillator, respectively. The wide frequency deviation, single filter/envelope detection system and the narrow frequency deviation, single filter/differential detection system are studied. In these two systems, the intermediate frequency (IF) center frequencies are stabilized at 1.05 GHz \pm 1 MHz and 810 MHz \pm 1 MHz, respectively, by an AFC. After the 140 Mbit/s, 24-bit NRZ programme is transmitted through 6.4 kilometers of single-mode optical fiber (the loss is about 0.62 dB/km), it was mixed, amplified, bandpass filtered (0.639-1.1 GHz) and demodulated by an envelope detector or a differential/delay-line demodulator. The demodulated baseband signal was amplified, post-detection filtered (0-98 MHz), sampled and then fed into a decision circuit. The measured system performances are: Bit Error Rate (BER) $\leq 10^{-9}$ (observed within half an hour), receiver sensitivity is -37.7 dBm (BER $\leq 10^{-9}$), span loss margin is 24.92 dB. In the experiments, the IF circuits are designed optimally; meanwhile, the frequency modulation characteristics of the transmitter are exhaustively studied by means of IF spectrum. The experimental results show that various kinds of coherent optical fiber communication systems can be set up, if the proper GRINROD external cavities are chosen.

**Lower Hybrid Current Drive Experiment
Successfully Conducted With HL-1 Tokamak***92P60385B Beijing RENMIN RIBAO [PEOPLE'S
DAILY, OVERSEAS EDITION] in Chinese 28 Jul 92 p 1*

[Article by Liu Xiaoge [0491 1420 7245]: "New Breakthrough in Nation's Nuclear Industry Technology"]

[Summary] Chengdu, 26 Jul (XINHUA wire report)—The nation's nuclear industry technology specialists have just realized another breakthrough advance: scientists at the nuclear industry's Southwest Institute of Physics recently conducted their first successful lower hybrid current drive (LHCD) experiment with the China HL-1 tokamak. In this experiment with the LHCD technique—an advanced method for confining plasmas and suppressing plasma instabilities in magnetic-confinement fusion apparatus—the scientists were able to drive a 40-kiloampere plasma current with a pulse width of 100 milliseconds. In comparison to similar experimental data obtained at other domestic tokamak facilities, this pulse width is over 300 percent longer, current is over 200 percent higher, and driving efficiency is 400 percent higher.

**200,000-Gauss Steady-State Intense Magnetic
Field Apparatus Certified***92P60385A Hefei ANHUI RIBAO in Chinese 3 Jul 92 p 1*

[Article by Peng Dejian [1756 1795 1696]: "Nation's Largest Intense-Magnetic-Field Experimental Apparatus Completed"]

[Summary] The 200,000-gauss hybrid-magnet steady-state intense magnetic field experimental apparatus developed in an 8-year effort by the CAS Institute of Plasma Physics (IPP) passed expert appraisal on 23 June. The development of this apparatus—the largest such equipment in the nation—propels China into the front ranks of world R&D of intense magnetic field technology, which is used for studying the physics of matter under extreme conditions. The IPP group, led by Research Fellow Gao Bingjun [7559 4426 6874], successfully attained the 200,000-gauss design value with this apparatus, consisting of water-cooled coils and superconducting coils, on 23 May [1992].

**NSA-Funded Major and Special Physics
Programs in the Seventh 5-Year Plan***92Fe0446A Beijing WULI [PHYSICS] in Chinese
Vol 21 No 1, Jan 92 pp 25-31*

[Article by Department of Mathematical and Physical Sciences, National Natural Science Foundation: "Major Programs and Special Programs in Physics Funded by the Natural Science Foundation During the Seventh 5-Year Plan"]

[Text] Abstract: The major programs and special programs funded by the Department of Mathematics and Physics of the National Natural Sciences foundation during the Seventh 5-Year Plan are surveyed, the principal investigators and investigations performing the work are listed, and the subject matter of the research and the expected scientific data are described. A table gives the funding levels and time frames of the research.

During the Seventh 5-Year Plan, based on the recommendations of the departments and of experts in the field the Physics and Mathematics Department of the National Natural Sciences Foundation (NSF) selected a group of projects of major significance, with clear-cut objectives, for which solid capabilities were available, and which were of major importance to progress in their respective fields or for high technology, new technology, and economic construction. After discussion, preliminary presentations and evaluation, 10 major programs and one special program in the field of physics were established (see Table 1). These programs are now all under way, and some of them have already made significant progress, obtaining high-level results that have international influence. Starting this year, the projects for the Seventh 5-Year Plan will be in the concluding and acceptance stages. New major projects for the Eighth 5-Year Plan are being worked out and organized. In addition, new key programs are being processed this year. Physicists are watching the process closely and are eager to assure that the work is done even more effectively, and we welcome everyone's valuable opinion and suggestions. We now briefly describe the major projects and special project for the Seventh 5-Year Plan.

Table 1. Major Projects and Special Projects of Seventh 5-Year Plan

Number	Name of Project	Principal Investigator	Organization	Level of Support (million yuan)	Period
9187001	New Nonlinear Crystals and Laser Crystals	Feng Duan [7458 4551]	Beijing University	1.5	1987-91
9187002	Structure and Electron States of Solid Surfaces and Interfaces	Xie Xide [6200 1585 1795]	Fudan University	1.5	1987-91
9187005	Semiconductor Superlat- tice Microstructure	Huang Kun [7806 2492]	Institute of Semiconduc- tors, CAS	2.0	1987-91
9187008	Some Leading-Edge Topics in Theoretical Physics	Zhou Guangzhao [0719 0342 2507]	Institute of Theoretical Physics, CAS	1.0	1988-92
9187009	Structure and Properties of Quasicrystals	Guo Kexin [6753 0668 0207]	Beijing Electron Micro- scope Laboratory, CAS	0.88	1989-91

Table 1. Major Projects and Special Projects of Seventh 5-Year Plan (Continued)

Number	Name of Project	Principal Investigator	Organization	Level of Support (million yuan)	Period
9188004	Microscopic Interaction of Electrons with Ions, Atoms, and Molecules	Yu Min [0060 2404]	Beijing Institute of Applied Physics and Computational Mechanics	1.32	1989-93
9188005	Interaction of Laser Light with Atoms and Molecules	Zhang Zhiming [4545 1807 7686]	Fudan University	1.18	1989-93
9188006	Interaction of Laser Light with Condensed Matter	Yang Guozhen [2799 0948 2823]	Institute of Physics, CAS	1.25	1989-93
9188007	Physics of Noncrystalline Semiconductors	Xu Wenyuan [1776 3306 0337]	Nankai University	0.82	1989-93
9189011	Development of a Supersensitive Small Cyclotron Mass Spectrometer	Chen Maobo [7115 5399 2672]	Shanghai Institute of Atomic and Nuclear Physics, CAS	0.55	1989-91
Special project	High-Energy Heavy-Ion Collision Physics	Liu Yiming [0491 0076 6900]	Harbin Industrial University	0.40	1989-91

I. New Nonlinear Crystals and Laser Crystals

As high technology develops, there is a steady increase in the variety of nonlinear crystals and laser crystals with outstanding properties; these crystals not only have expanded the range of wavelengths in which high-power lasers can be applied, but in addition are increasingly revealing their importance for optical communications, optical signal processing, and optical computers. Consequently, the investigation of new nonlinear optical crystals and laser crystals is attracting the close attention of scientists in all countries. The discovery and development of such crystals relies especially on basic research in solid state physics, solid state chemistry, and materials science and on a close integration of basic research with materials synthesis, and crystal growing techniques. Research performed under this program is likely to be of major importance in advancing China's laser and optoelectronic technology and will also promote the development of the above scientific fields in China.

Research on nonlinear optical crystals and laser crystals is already at a high level. We are capable of conducting independent explorations and developing new crystals. Many new concepts and techniques have already appeared. Certain high-technology monocrystals have already won high praise internationally and are being exported, creating foreign exchange. For example, the Fuzhou Materials Structure Institute, CAS, made a basic theoretical study of the frequency doubling effect in crystals and developed β -BaB₂O₄ crystals, which are one of the most important crystal varieties worldwide. The Shandong University Crystal Institute's KTP crystals have set new standards in both quality and size.

This program is being carried out cooperatively by units that have advanced equipment and capable personnel skilled in the preparation of nonlinear optical crystals and the measurement of laser crystal characteristics. Each organization has distinctive strong points.

The principal subject matter of the research and the expected results are as follows.

A. Develop and improve the theory of nonlinear optical crystals and other functional crystals in the category of metal-organic complexes, and grow 2 or 3 nonlinear materials or laser materials with significant applications.

B. Develop new lithium borate frequency multiplier crystals for use in high-power neodymium-doped lasers, and specifically in China's highest-power laser devices. Thoroughly investigate the optoelectronic properties of LBO crystals and the theory of ultraviolet nonlinear optical crystal materials.

C. Investigate and develop new polysynthetic, polydomain crystal materials with frequencies in the microwave region. Elucidate the relationship between crystal defects and microstructure properties, and develop new functional materials with modulated structure.

D. Make a comprehensive experimental and theoretical investigation of crystal fields and electroacoustic coupling in high-valence cation phonon-terminal tunable laser crystals, and develop distinctive new materials.

E. Investigate growth and defect formation of lithium-doped and Li/Nb balanced lithium niobate (LN) crystals and study the self-pumped optical conjugation effect in certain crystals.

These five topics are respectively headed by Zhang Minhua [5592 3046 5478] (Shandong University), Chen Chuangtian [7115 0482 1131] (Fujian Institute of Materials Structure, CAS), Feng Duan [7458 4551] (Nanjing University), Luo Zundu [5012 6690 1653] (Fujian Institute of Materials Structure, CAS), and Tan Haoran [6223 3185 3544] (Shanghai Silicates Institute, CAS).

II. Structure and Electron States of Solid Surfaces and Interfaces

Modern physics has already demonstrated that the surfaces of solids have greatly different properties from their

interiors: for example, adsorption, catalyzed reactions, and many other processes take place directly on the surfaces or at interfaces. The requirements of the materials, information and energy fields, among others, have promoted research on solid surfaces and interfaces, and the subject is now recognized throughout the world as a leading-edge discipline.

Research on atomic structure and electron states is at the core of surface and interface research, because only by understanding these aspects is it possible to elucidate the microscopic properties of surfaces and the physical and chemical processes that take place on them so as to lay a solid foundation for application technologies. New methods and equipment for investigating surface structure and electron states have been developing rapidly in recent years, and there is an increasing number of powerful tools for research science. For example, reflection electron spectroscopes and scanning tunneling microscopes have achieved major results in such areas of surface science as new metals, semiconductors, and adsorption systems.

Our understanding of atomic structures and electron states on surfaces and interfaces is much less mature than our understanding of the corresponding structures and states within solids. Only a few relatively uncomplicated surface atomic structures are now clearly understood. Such questions as the origin of surface electron states, their relation to surface structure, and the effect of surface states on semiconductor Fermi-level spikes and on Schottky barriers still await complete answers.

China began research on surface structures and electron states in the 1980's. An adequate foundation has now been laid in the field, and some surface analysis instruments have been created. During the Sixth 5-Year Plan, the units working under this program had some splendid results in surface physics. The research topics selected under the program involve material systems with major applications prospects and theoretical significance in current information science and material science: namely, investigation of the atomic structure and electron states of clean surfaces and adsorbing surfaces and heterostructures, and the development of new methods and devices that can be applied to surface research.

The research topics include: semiconductor superlattice and heterostructure interfaces, surfaces and interfaces of semiconductors based on group III, IV and V elements, structures and electron states of silicon compounds, surface structures and electron states of transition metals, rare earth metals and precious metals, surface atom segregation and its effect on structure and electron states, and new methods of investigating surface structures and electron states. These projects are being headed by Wang Xun [3769 6598] (Fudan University), Xu Zhenjia [6079 2182 0587] (Semiconductor Institute, CAS), Wu Encheng [0702 1869 6134] (Beijing University), Lin Zhangda [2651 1757 6671] (Institute of Physics, CAS), Li Risheng [2621 2480 0581] (Shenyang Metals Institute, CAS), and Hua Zhongyi [5478 0022 0001] (Fudan University).

III. Microstructure of Semiconductor Crystal Superlattices

Semiconductor superlattice microstructure is a major leading-edge area of research in semiconductor physics and devices. It involves basic research on many physical phenomena, but also has clear-cut applications prospects and will produce a major influence on semiconductor devices and electronics technology.

Semiconductor superlattice microstructure is based on electron-beam epitaxy (MBE) and metal-organic chemical vapor deposition (MOCVD). A series of major physical phenomena occur in such low-dimensionality electron systems as superlattices and quantum wells. Not only do electron states, impurity states, exciton states, and phonon and plasmon elementary excited states in low-dimensionality systems exhibit attributes from those in three-dimensional solids, but in addition, certain quantum effects not occurring in three-dimensional solid systems have now been discovered: the quantum Hall effect and the fractional quantum Hall effect are major examples. Among superlattice quantum-well low-dimensionality structures, quantum coherent conductance phenomena constitute an important development in present-day solid state physics and provide the physical basis for the design of the next-generation ultralarge scale integrated circuits. As a consequence, superlattice physics represents a new level in semiconductor physics that has ushered in a new stage in the development of solid state electronic components and optoelectronic devices. Since composition, doping and structure can be controlled at the atomic scale, superlattice physics provides major potential for designing a new generation of solid state components, and, even more important, the new physical phenomena and effects that occur in superlattice structures have extensive prospects for device applications. For example, the exciton-absorption saturation that is produced by the limited dimensionality of quantum wells is used to form exciton bistable optical devices that have fast conduction, good high-frequency characteristics, low energy consumption, and reliable high-temperature performance, as well as a new generation of quantum devices whose switching speed can be in the picosecond range.

Internationally, R&D in this area is in a period of vigorous development. Molecular beam epitaxy has developed rapidly from the initial research stage to the industrial application stage, and the new production technology of chemical beam epitaxy (CBE or MOMBE) emerged. As a result, a variety of new superlattice quantum-well electron devices and optoelectronic devices have been developed, such as quantum-well laser devices, exciton bistable optical devices and the like. In addition, superlattice quantum-well physics research is developing in depth and is becoming the leading area of research in semiconductor physics. China has already laid a satisfactory foundation in this field. Development projects since 1980 include molecular beam epitaxy equipment, variable-doped GaAs/AlGaAs heterojunctions with migration rates of 3.3×10^5 cm²/V-sec, and multiple quantum-well structures with 50-angstrom well width. Room-temperature pulsed emission from a quantum well laser device was obtained in 1986. Many results have also been obtained in superlattice

quantum well theory and in related experimental studies, and some have opened up prime areas of world research. But we are still considerably behind the world state of the art, and there is an urgent need to step up the pace of research.

This program focuses on investigating a new generation of electron devices and optoelectronic devices, with an emphasis on basic research on semiconductor superlattice microstructure, including the preparation of semiconductor superlattice and quantum-well materials, device investigation, and physical research. The research topics are: semiconductor superlattice and quantum-well lattice dynamics and electron structure, transport processes in superlattice low-dimensionality systems, semiconductor superlattice quantum-well optics, nonlinear characteristics of superlattice and multi-quantum-well structures, superlattice physics of noncrystalline semiconductors, processes for the preparation of one-dimensional quantum lines, semiconductor superlattice and quantum-well optoelectronic devices and their physics, the use of electron beam epitaxy to prepare superlattice microstructures of group IV and V elements, and superlattice quantum-well deep energy levels. The work is being performed by Xia Jianbai [1115 1696 4101], Zheng Houzhi [6774 0624 2784], Ge Weikun [5514 1919 6924], Wu Ronghan [0702 2837 3352], Kong Meiyang [1313 2734 1758], and Zhou Jie [0719 3381] of the Semiconductor Institute, CAS, Gu Shijie [7357 0013 2638] and Zhou Junming [0719 0971 6900] of the Institute of Physics, CAS, and Chen Kunji [7715 0981 1015] of Nanjing University.

IV. Major Cutting-Edge Problems of Theoretical Physics

Using the full range of physical experimentation and observation, and applying deduction and mathematical induction, theoretical physics is continuously revealing the basic natural laws that control the material world, explaining experimentally observed facts, predicting new phenomena, guiding physical experiments and observation at a new high level, promoting the development of all areas of physics and of natural science as a whole, and providing scientific evidence for the cosmology and world view of dialectical materialism. The research results obtained by theoretical physics are the theoretical basis of such new technologies as atomic energy, semiconductors, information, lasers, space flight, and electronics, and of many modern high-S&T areas. The research cycle in theoretical physics is short, it is a highly competitive field, and it helps to nurture specialists with a wide range of supporting capabilities. A well trained theoretical physics contingent is a national strategic reserve that can if necessary be used to solve major defense or development problems. The USSR, the US, and the countries of Western Europe have large, advanced physics contingents. In China, we should give appropriate support to a high-level theoretical physics contingent so that China's research in theoretical physics will be at a high level and will produce results of international significance in the fields where we have a solid foundation and strong capabilities, thus bringing us for the first time into the world forefront; attaining this objective is of great importance.

The topics under this program include the theoretical investigation of chaos in nonequilibrium systems, theoretical research on certain problems in the theory of the condensed state and the quantum many-body problem, conformal invariant systems, quantum fields and their large-scale properties, the physics of charmed particles and the Standard Model, flavor multiplets and TeV [teraelectron-volt] physics. The work is being performed by Hao Bolin [6787 2672 2651], Su Zhaobing [5685 5128 0393], Guo Hanying [6753 3352 5391], and Huang Tao [7806 3447] of the Institute of Theoretical Physics, CAS, and Zhao Guangda [6392 0342 6671] of Beijing University.

These are cutting-edge topics in the mainstream of current theoretical physics. Theoretical physicists throughout the world are focusing their efforts on these topics, and the competition is intense. Overall, in terms of research on the basic structure of matter and the nature of its interactions, this program includes the topics on charmed particles and flavor multiplets, which are chiefly related to experimental studies, but also incorporates pure theoretical subjects that deal with basic principles. It includes the subject of condensed matter, which is currently one of the most active and competitive areas of research worldwide and is the key to theoretical applications, and the subject of chaos, whose applications extend beyond the realm of physics and which reveals the inner laws of complex, nonlinear systems. These topics are relevant to a wide range of other fields, and each is a distinctive discipline in which creative thinking is being done; the topics are mutually interrelated and interpenetrating, with cross-fertilization between physical thinking and research methods, and represent current trends of development in physics research.

V. Structure and Properties of Quasicrystals

Until 1984, it was believed that all solids were either crystalline or noncrystalline. In crystals, the atoms have not only short-range order, but also periodicity. In non-crystals (such as glasses), there is only short-range order but no long-range order, and periodicity of arrangement is absent. Owing to periodic translation of the atomic arrangement in crystals, they could have 2-, 3-, 4- or 6-fold symmetry, but rotational symmetries of 5 or greater than 6 were not permitted.

In 1984, Shechtman et al. first reported the discovery of a clear-cut fivefold electron diffraction pattern in a rapidly solidified lead-magnesium alloy, indicating that the atomic arrangement in this alloy had fivefold rotational symmetry. This discovery overturned certain ideas about crystals that had been held for several centuries and has led to major upheavals in all fields of solid state physics that are based on crystallography. It broke down the traditional concept of crystals and established the new science of quasicrystals, in which the atoms have an orderly positional arrangement but no periodic arrangement.

The primary subject matter of quasicrystal science is: quasiperiodic lattices, abnormal rotational symmetries, phase changes and stresses, dislocations and [gongdu] defects, and the transition from the quasicrystalline to the crystalline state.

Since the first discovery of quasicrystals, the subject has been a popular area of study in condensed-matter physics

and crystallography. Chinese investigators have made breakthroughs in the field. Fivefold symmetry was discovered in 1984; in 1985 transition-metal quasicrystals were discovered; and in 1987, quasicrystals with eightfold symmetry were first discovered. These ground-breaking studies attracted serious attention from international academic circles. In 1987, the second international congress on quasicrystallography was held in Beijing.

This program includes the following research topics: the growing and processing of quasicrystals, quasicrystal alloys, quasicrystal crystallography and structural models, quasicrystal phase changes and defects, and the physical properties and electron theory of quasicrystals. The work is being done by Guo Kexin [6753 0668 0207] of the Beijing Laboratory of Electron Microscopy CAS, Ye Hengqiang [0673 1854 1730] and Yang Qibin [2799 1142 2430] of the Shenyang Metals Research Institute, CAS, Li Fanghua [2621 2455 5478] and Zhao Jiangao [6392 6015 7559] of the Institute of Physics, CAS, and Wang Renhui [3769 0088 0583] of Wuhan University.

VI. Experimental and Theoretical Investigations of the Microscopic Interaction of Electrons With Ions, Atoms, and Molecules

Research on the way in which electrons interact with ions, atoms and molecules is a major aspect of the investigation of the microscopic structure of matter and of the laws of motion governing the microscopic material world. Experimental measurements and theoretical calculations have been used to obtain electron collision excitation cross sections, ionization cross sections, scattering cross sections and the like, which have important applications in many fields of technology. In particular, in magnetic-confinement nuclear fusion, laser-induced nuclear fusion, and X-ray laser research, there is a pressing need for large bodies of electron collision data relating to highly ionized atoms. Owing to the experimental difficulties and the huge amount of labor involved, this is an arduous, long-term undertaking. Over a period of more than 10 years, the technologically developed countries such as the US, the Soviet Union, Japan and the countries of Western Europe have committed major amounts of manpower, material resources and funding to electron collision studies and have engaged in a variety of investigations that have yielded numerous results. Nonetheless, there are still many gaps. If, in line with China's actual circumstances, we organize several units with a solid foundation, select several significant topics, and gradually put together a full complement of experimental equipment, so as to build up a contingent that will produce some results of international significance, major progress could be made in overcoming China's weakness in atomic and molecular physics.

This program includes the development of experimental equipment, theoretical computation methods and computer programs for investigating electron and ion collisions. It focuses on electron collision data that are needed for work on X-ray lasers and laser-induced nuclear fusion, high-precision experimental studies and basic theoretical research on collisions of electrons with atoms and ions, and the use of electrons as probes to investigate the microstructure of atoms and molecules. The specific topics are: electron collision cross sections of medium-Z elements

in low ionization states and of hydrogen-like and helium-like ions of carbon, which is being conducted by Yang Fujia [2799 4395 1367] and Tang Jiayong [3282 1367 6978] of Fudan University; spectral investigations of excited states and highly ionized states resulting from the collision of electrons with atoms and ions, being carried out by Pan Guangyan [3382 0342 3508] of the Institute of Physics, CAS; determination of the energy spectrum cross sections of electron scattering by atoms and molecules and of the scintillation properties of the products, conducted by Wang Renguang [3769 0088 0342] of Chengdu S&T University; research on inelastic collisions of electrons with atoms and molecules, conducted by Xu Kezun [1776 0344 1415] of China S&T University; theoretical analyses of electron-ion interactions and ion spectra, performed by Sun Yunsheng [1327 3057 4141] of the Beijing Institute of Applied Physics and Computational Mathematics; theoretical calculation of the electron scattering cross sections of atoms and molecules, performed by Zhao Yijun [6392 0122 0689] of the Changsha National Defense S&T University; and theoretical studies of the microscopic interaction of slow electrons with atoms and molecules, conducted by Gou Qingquan [5384 3237 3123] of Chengdu S&T University.

VII. Atomic and Molecular Interactions With Laser Light

The interaction of atoms and molecules with high-energy-density coherent laser light is a mainstream aspect of current research in atomic and molecular physics and chemistry and also an important means of exploring the basic laws of physics, of understanding the structure of matter, and of investigating material changes at the atomic and molecular levels.

In the past 10 years, as a result of progress in laser technology, molecular beam technology, and data collection and processing, combined with theoretical advances, research in atomic and molecular physics has been flourishing and has achieved noteworthy results. Some measurements have reached levels of precision that are unattainable in other sciences. Traditional concepts of the structure of matter have been revised in some areas. At the same time, research on the interaction of laser light with atoms and molecules has provided major theoretical foundations, experimental techniques and basic data for other branches of physics, such as the physics of condensed matter, plasma physics, astrophysics, surface physics, and related areas such as astronomy, chemistry and biology. It has provided a powerful impetus to progress in the development of new technologies, new materials, new equipment and new methods, and is exerting a far-reaching influence on China's industrial and energy development and environmental protection.

Research on the interaction of laser light with atoms and molecules is currently proceeding vigorously throughout the world. It is forecast that the rate of advance in the next decade will exceed that of the past 10 years. The US, Western Europe, Japan and the Soviet Union are committing large amounts of personnel and resources to research in this field. Since the 1970's, China too has been working in the area; in the field of the laser spectra of atoms, it has

carried on experimental and theoretical work on the Rydberg spectra of alkali metals, alkaline earth metals, and rare earth metals, the spectra of highly ionized atoms, and multistage excitation and ionization spectra of atoms. Work in the molecular field includes: high-resolution molecular spectroscopy, multiphoton ionization spectra and multiphoton ionization dynamics, dimer and trimer spectra of alkali metals, and the spectra of superfast molecular processes. Some of this work is already on a par with the world state of the art and has attracted international attention. But in some areas, progress has been limited by conditions and our work is not thorough or penetrating enough, so that we are somewhat behind the world state of the art. As a consequence, cooperation has been organized between several organizations with solid capabilities, and several topics of world interest have been selected for joint research.

Research topics under the program include: spectra of atoms in highly excited states, conducted by Wang Zugeng [3769 4371 6342] of East China Normal University, Shanghai; spectra of ionized molecules in the gaseous state and the matrix isolation state and laser spectra of light-sensitive biological molecules and medicinals, conducted by Li Fuming [2621 1381 6900] and Yang Yuanlong [2799 6678 7893] of Fudan University; studies of Rydberg states and free ionized states and of the interaction of strong laser radiation with highly ionized atoms, conducted by Lin Fucheng [2651 4395 2052] and Xu Zhizhan [1776 5267 1455] of the Shanghai Institute of Optics and Precision Mechanics, CAS; inelastic interaction of supershort pulses with atomic and molecular systems and the temporal resolution spectra of complex molecules and macromolecules, conducted by Gao Zhaolan [7559 0340 5695] and Xu Zhenxin [1776 2182 2450] of Zhongshan University; and metastable molecules and their interaction with laser light, conducted by Zhang Daozhong [1728 6670 0022] of the Institute of Physics, CAS.

VIII. Research on Some Leading-Edge Problems of the Interaction Between Laser Light and Matter in the Condensed State

The condensed state of matter is the physical state which we ordinarily encounter. Condensed-state physics is an integrated fundamental science that investigates the physical properties, structure and internal laws of motion of materials in this state. It is a major branch of physics and is also a major scientific foundation of materials science, solid-state electronics, and optoelectronics. Progress in this field has a major bearing on new-technology industries and on the industrial revolution. The applications prospects of the revolutionary changes in optics brought about by the appearance of the laser and by recent breakthroughs in high-temperature superconductivity are excellent examples.

Research on the interaction of laser light with the condensed state of matter can provide important information on the composition, structure and states of materials, on energy coupling and transitions, and on internal motions. In turn, this information can also provide a reliable basis for the development of new materials and the application of new technological principles.

The laser has become an extremely important tool for investigating the condensed state of matter. Such countries as the US, the USSR, Western European nations, and Japan have made major efforts in investigating the interaction of laser light with the condensed state of matter, and some top laboratories are working on the subject. China already has rather solid credentials in this research. Its capabilities are concentrated primarily in major research institutes of the CAS and in a few key universities. The research units that have responsibilities under this program are at a rather high level and are capable of taking part in international exchange and competition.

The research topics under this program include: effects and mechanisms of the interaction of laser light with new materials, new research techniques for studying them, optical chaos, and strong nonlinear optical effects, respectively under the leadership of Ye Peixian [0673 0160 1720] and Zhang Hongjun [1728 3163 6874] of the Institute of Physics, CAS; semiconductor optical nonlinearity and coherence spectra, conducted by Zhang Guangyin [1728 0342 1377] of Nanjing University; and the interaction of laser light with surfaces and interfaces, headed by Zheng Zhaopiao [6774 1367 7516] of Fudan University.

IX. Leading-Edge Research in Noncrystalline Semiconductor Materials

Noncrystalline semiconductor materials science is a new branch of the physics of condensed matter. Noncrystalline semiconductors have many properties that differ from those in the crystalline state, and the variety of their components and methods of formation results in their having many new physical properties that can serve as the basis for device design. Internationally, about a dozen devices such as noncrystalline silicon solar batteries and line image transmission devices are already in existence. The application of thin film field effect transistors (TFT) to large-area flat-screen displays will supplant the CRT [cathode-ray tube] technology common in the 1990's and will have a major influence on electronic products.

An extensive applications background has provided many research results in basic physics and device physics, such as silane and silicon-like plasma reactions and dynamic deposition processes, electron defect states and impurity states in noncrystalline semiconductor materials, the microstructure and metastable state characteristics of nonlinear semiconductors, electron transport mechanisms in various device structures, and, most recently, new alloy materials such as nanometer silicon, microcrystalline silicon, and alternating broad and narrow bandgap silicon alloys.

In the last 10 years, China has done a great deal of work in this new field and has put together good experimental conditions, accumulated abundant experience, and nourished new productive capabilities. In response to scientific development, the following research topics have been selected: film formation mechanisms of nonlinear silicon-based alloys, noncrystalline silicon defect states and metastable states, carrier transport mechanisms, new materials using silicon-based alloys, the microstructure of noncrystalline silicon thin films and their conversion to microcrystalline forms. The work is being performed by Cheng Ruguang [4453 1172 0342] of the Shanghai Institute of

Silicates, CAS, Sun Guanglin [1327 0342 5259] of the Institute of Semiconductors, CAS, Xu Wenyuan [1776 3306 0337] of Nankai University, Chen Guanghua [7115 0342 5478] of Lanzhou University, and He Yuliang [0149 1342 0081] of Nanjing University

X. Supersensitive Small Cyclotron Mass Spectrometers

Since the 1970's, the acceleration mass spectrometer (AMS) has been a specialized tool for ion beam analysis. As a new application of accelerators, it not only provided world science with a technique for the age of ultramicroscopic analysis and precision measurement, but also became a device for many types of scientific research, with important applications in planetary physics, geology, marine science, meteor science, archaeology and the like. Recently its range of applications has broadened further to include environmental chemistry, materials science, and biomedical science; it has been important in economic development and has provided important information for urban, seaport and oilfield construction, the location of groundwater sources, and earthquake monitoring.

There are now more than 30 AMS laboratories worldwide. Most of the AMS devices that are in operation are large tandem accelerators. China has about 50 units engaged in materials dating activities that have a pressing need for AMS technology. But the construction, operation and maintenance costs of the current large accelerators are rising, which is hindering the expanded use of AMS technology. If small cyclotron mass spectrometers could be used as a dedicated low-energy supersensitive mass spectrometer, in addition to combining the desirable features of large tandem mass spectrometers and cyclotron mass spectrometers, it would have the further advantages of compact structure, low construction cost, inexpensive maintenance and operation, and ease of use and would be free of the cost of special radiation-proof construction. In addition, it could be installed in ordinary buildings. The development of small cyclotron mass spectrometers includes several complex requirements. The only organization anywhere in the world currently working on the problem is the Berkeley laboratory in the United States, but it has not yet been successful.

In order to develop a supersensitive small cyclotron mass spectrometer, the organizations working in this program have made a thorough theoretical analysis of similar mass spectrometers under development abroad and have come up with an entirely different physical design concept and technology approach. For example, the proposed triangular-wave D-voltage accelerator technology and discrete fan-shaped isochronous magnetic field are innovative approaches and will have advanced capabilities. This research program involves a competition with the Berkeley laboratory in the US, and if it should be successful, there is the prospect of attaining the world state of the art in low-energy AMS research.

The topics under this program are: development of a triangular-wave system, development of a non-electrically compensated, highly adjustable isochronous field magnet, research on a pulse-modulated energy injection system, development of high-sensitivity, low-background, low-energy single-particle detection equipment, and theoretical and laboratory research on epoch-making small cyclotron accelerator applications. The work is being performed by Lu Songlin [4151 1345 2651], Zhang Xilin [1728 6932 7792], Mao Yu [3029 5038], Zhang Yingji [1728 2503 4614], and Xu Senlin [1776 2773 2651] of the Shanghai Institute of Atomic and Nuclear Research, CAS.

XI. Special Project on High-Energy Heavy-Ion Collision Physics

High-energy heavy-ion collision physics is a leading-edge field of science that has been developing rapidly. Relativistic nucleus-nucleus collisions can cause the nuclear medium in the collision zone to form extremely high-temperature, high-density states. Research on the states of the nuclear medium under these extreme conditions has a direct bearing on many major problems of nuclear physics, particle physics, and planetary physics and thus is a subject of close attention by the physics and planetary physics community worldwide.

There have been a variety of theoretical conjectures regarding the nature of the nuclear medium. QCD [quantum chromodynamic] lattice gauge calculations have predicted the existence of a new phase of the nuclear medium, namely, the quark-gluon plasma. Various phenomenological theories of relativistic nucleus-nucleus collisions have been proposed, and as a consequence, analysis of the experimental data, elucidation of the phase diagram of the nuclear medium, the development of a phenomenological theory of relativistic nucleus-nucleus collisions and the finding of evidence for the existence of the quark-gluon plasma have become extremely important. In recent years, US and Western European countries have committed large amounts of manpower and funds to research in high-energy heavy-ion collision physics, and heavy-ion accelerators capable of attaining ever-higher energies are being built. A relativistic heavy-ion collider (RHIC) is already planned.

This project makes use of the excellent cooperative relationship between the Harbin Industrial University's Laboratory of Theoretical Physics, the physics department of the University of California at Riverside, and the physics department of Kent State University. It involves a theoretical analysis of the relativistic nucleus-nucleus collision streamer data obtained by the Lawrence Berkeley Laboratory, with an emphasis on pion interferometry, pion-source space-time analysis, an analysis of aggregate lateral currents, and experimental analysis of the nucleus-nucleus collision model.